

Earth Science Workshop 2



UNDERSTANDING the ATMOSPHERE and OCEANS

SEYMOUR ROSEN



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THE AUTHOR

Seymour Rosen received his B.A. and M.S. degrees from Brooklyn College. Mr. Rosen taught science at the Edward B. Shallow Intermediate School in Brooklyn, New York for twenty-three years. He currently teaches at the Springfield Gardens Intermediate School in Queens, New York.

Mr. Rosen was a contributing participant in a teacher-training program for the development of science curriculum for the New York City Board of Education.

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BEFORE YOU BEGIN . . .

Have you ever gone to a ball game or an outdoor concert only to get "rained out"? Have you ever listened to the radio to find out if heavy snow has closed your school?

Weather affects all of our lives. A weather report may have helped you decide how to dress this morning!

In this book you will learn many things about the air that surrounds the earth and the vast oceans that cover three-quarters of its surface. You will find out why winds blow and how raindrops form. You will learn why the ocean is salty. You'll become an expert on reading weather maps—and learn how to make them yourself.

This book is set up in a special way. Each Aim begins with the things you'll need to know. This is followed by a series of exercises. Take your time on these. And look back to the beginning of the Aim when you're not sure of an answer. There will be experiments along the way—and a few surprises, too.

So get ready. The prediction sure looks good!

SCIENCE SAFETY

Science is the study of the world around you. The study of any branch of science includes "learning by doing." Investigations, experiments, demonstrations. Activities in which you are involved. You make things happen.

Safety is a very important part of these activities. Even if you are only reading about an investigation, you should know about the safety precautions that **MUST** be taken. The following **SAFETY ALERT SYMBOLS** are designed to call these precautions to your attention. They appear on pages wherever any of these dangers are present.



Safety Goggles



Lab Apron
or Coat

Safety goggles and a laboratory apron or coat should be worn for all activities or investigations.



Open Flame

When working near an open flame, be sure that hair and loose clothing are secured in some manner.



Poison

Many chemicals are poisonous, or toxic. Never taste, touch, or smell any unknown substance unless told to do so by your teacher.



Caustic Substances

Caustic (KAW stik) substances can burn your skin, eyes, and clothing. Handle these substances with extreme care. Acids and bases (such as lye) are caustic.



Toxic Vapors

Never inhale any vapors directly. To test the odor of a substance, use your hand to waft the vapors to your nose.



Sharp Objects

Always handle sharp objects with great care.



Broken Glass

Glassware, such as beakers, test tubes, glass tubing, and thermometers should be handled very carefully to avoid breakage. Never pick up broken glass with your bare hands.



Electric Shock

Never use electrical appliances near water or other liquids. Always inspect wiring for worn or broken insulation. Unplug all electric cords when not in use.

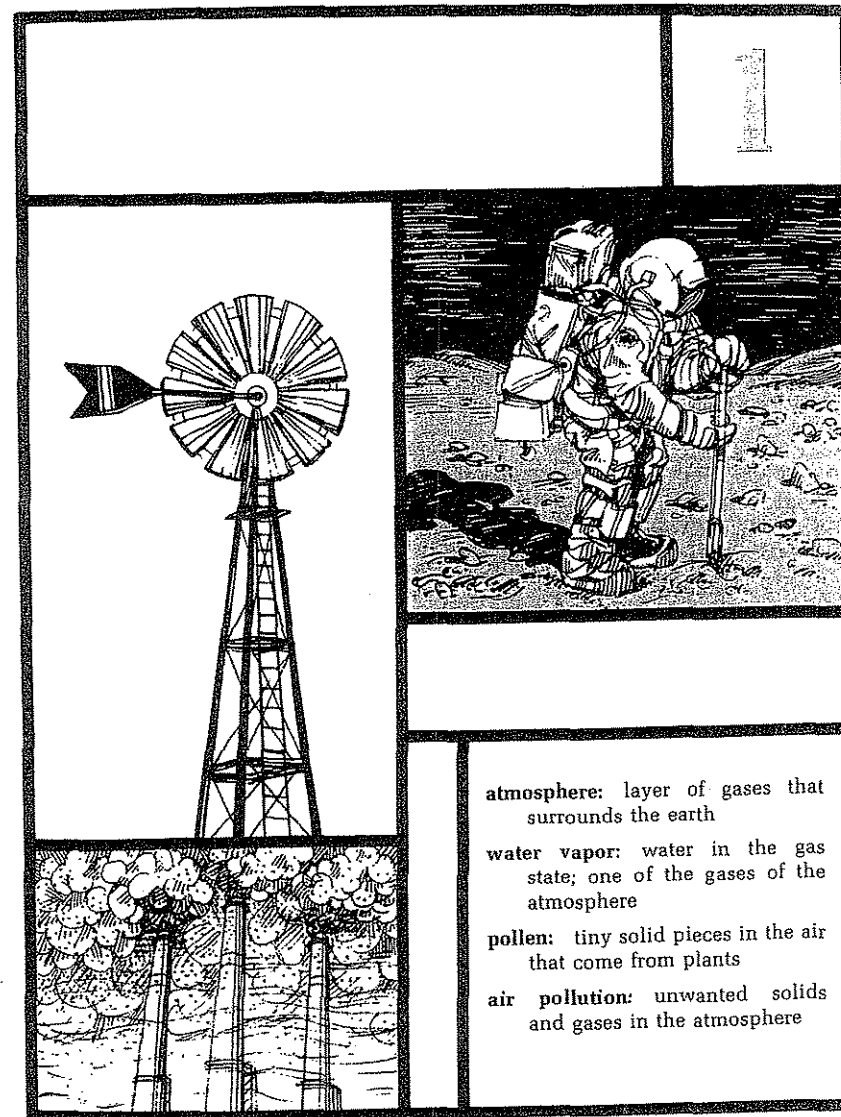


Hot Objects

When handling hot objects, use tongs or padded gloves. Never set hot objects directly on a desk or table top. Set them on a heat-resistant pad.

WHAT IS AIR MADE OF?

1



atmosphere: layer of gases that surrounds the earth

water vapor: water in the gas state; one of the gases of the atmosphere

pollen: tiny solid pieces in the air that come from plants

air pollution: unwanted solids and gases in the atmosphere

AIM | What is air made of?

1

Several Americans have walked on the moon. Some of them even rode among the craters in lunar "buggies." But the moon has no air of its own. So the astronauts had to take along their own—in tanks.

Take a deep breath. Go ahead—really do it! Do you need air tanks in order to breathe?

Our planet is not like the moon. Our planet has air. It is surrounded by an "ocean" of air. We call this ocean of air the atmosphere [AT muh sfeer].

Besides giving us air to breathe, the atmosphere is important in many other ways. It gives us our weather. It affects us when we ride in airplanes or walk.

The atmosphere is a mixture of gases. Nitrogen [NI truh jen] and oxygen [OK suh jen] make up most of this mixture. Small amounts of other gases make up the rest. They are carbon dioxide, water vapor, and certain "rare" gases.

The atmosphere also contains tiny pieces of solids like pollen, dust, and ash.

Most of the gases and solids of the air belong in the air. But some gases and solids do not. They did not get there in a natural way.

Gases and solids that do not belong in the air cause air pollution. These materials can be harmful.

There are many causes of pollution. Most air pollution comes from cars and factories. Some pollution comes from home chimneys.

Air pollution is a very serious problem.

COMPLETE THE GRAPH

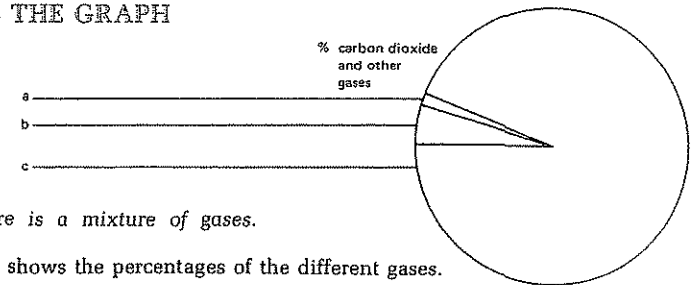


Figure A

The atmosphere is a mixture of gases.

This pie graph shows the percentages of the different gases.

1. About 78 percent of the atmosphere is nitrogen.

Write "NITROGEN-78%" on the proper line of the graph.

2. About 21 percent of the atmosphere is oxygen.

Write "OXYGEN-21%" on the proper line of the graph.

3. Figure this one out.

If the atmosphere has 78 percent nitrogen and 21 percent oxygen . . .

then

what percent is left for carbon dioxide and the other gases? _____

Write this number on the proper line of the graph.

WHAT DOES THE PICTURE SHOW?

Look at Figure B. Then fill in the blanks.

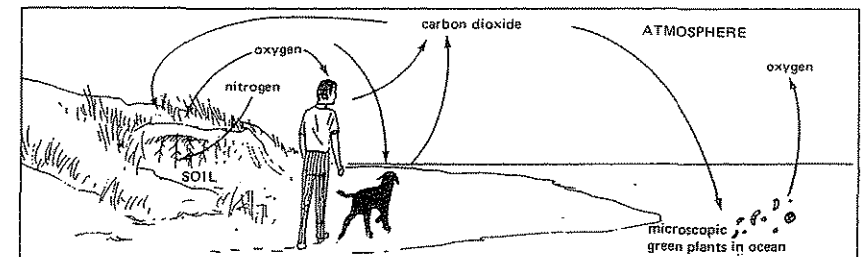


Figure B

1. All living things need _____
oxygen, carbon dioxide
2. Green plants also need the gas _____
carbon dioxide, nitrogen
3. Plants get the carbon dioxide they need from _____
the soil, animals
4. Animals get the oxygen they need from _____
the soil, plants
5. Nitrogen from the air becomes an important part of the _____
soil, ocean

WHERE DOES NATURAL DUST COME FROM?

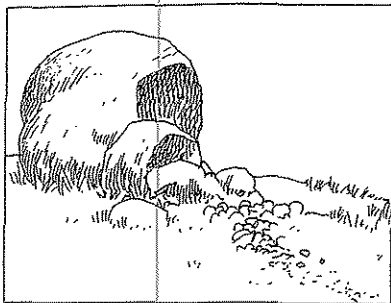


Figure C

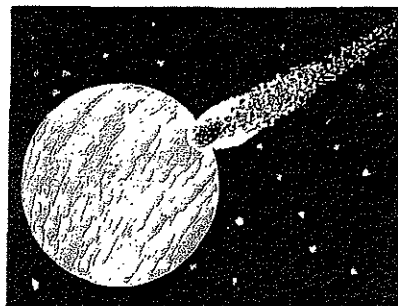


Figure D

Natural dust is formed in two ways:

Dust comes from broken-up rocks.

Rocks break into smaller pieces. Finally, they become the size of dust (Figure C).

Dust also comes from space.

Some dust comes from meteors that burn up in the atmosphere. Much more dust comes from deep outer space (Figure D).

Space dust adds about two million metric tons a year to the earth's weight. That's about 4½ billion pounds!

COMPLETING SENTENCES

Complete the sentences with the choices below.

air pollution
78%
pollen
water vapor
factories

nitrogen
atmosphere
automobiles
dust
21%

home chimneys
oxygen
ash
mixture of gases

- The ocean of air that surrounds the earth is called the _____.
- The atmosphere is made up of a _____.
- Water in gas form is called _____.
- Examples of tiny solid pieces in the atmosphere are _____, _____, and _____.
- Most of the atmosphere is made up of the gas _____.

- Nitrogen makes up about _____ of the atmosphere.
- The gas needed by all living things is _____.
- Oxygen makes up about _____ of the atmosphere.
- Unwanted gases and solids in the atmosphere cause _____.
- Three causes of pollution are _____, _____, and _____.

MATCHING

Match the two lists. Write the correct letter on the line next to each number.

- | | |
|--|--|
| 1. _____ atmosphere | a) needed by all living things |
| 2. _____ water vapor | b) tiny solids in the atmosphere |
| 3. _____ oxygen | c) mixture of gases that surrounds the earth |
| 4. _____ dust, pollen, and smoke particles | d) unwanted dust and gases |
| 5. _____ pollution | e) water in the gas form |

TRUE OR FALSE

Write T on the line next to the number if the sentence is true. Write F if the sentence is false.

- _____ Every ocean can be seen.
- _____ Every ocean is wet.
- _____ You are sitting in an ocean.
- _____ The atmosphere is an ocean of gases.
- _____ Most of the atmosphere is oxygen.
- _____ Oxygen makes up about 21 percent of the atmosphere.
- _____ Only animals need oxygen.
- _____ Water vapor is a gas.
- _____ Some dust is a natural part of the atmosphere.
- _____ Pollution is a natural part of the atmosphere.

WHERE DOES AIR POLLUTION COME FROM?

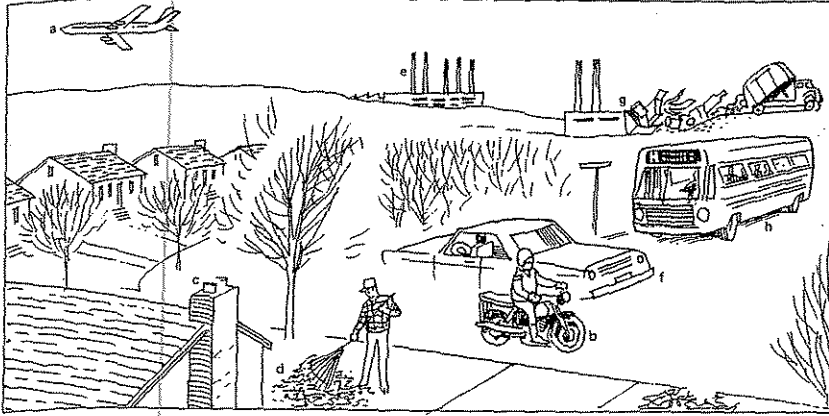


Figure E

Figure E shows some of the ways our air becomes polluted. How many of them can you find? Match the letters from the picture with the sources of pollution listed below.

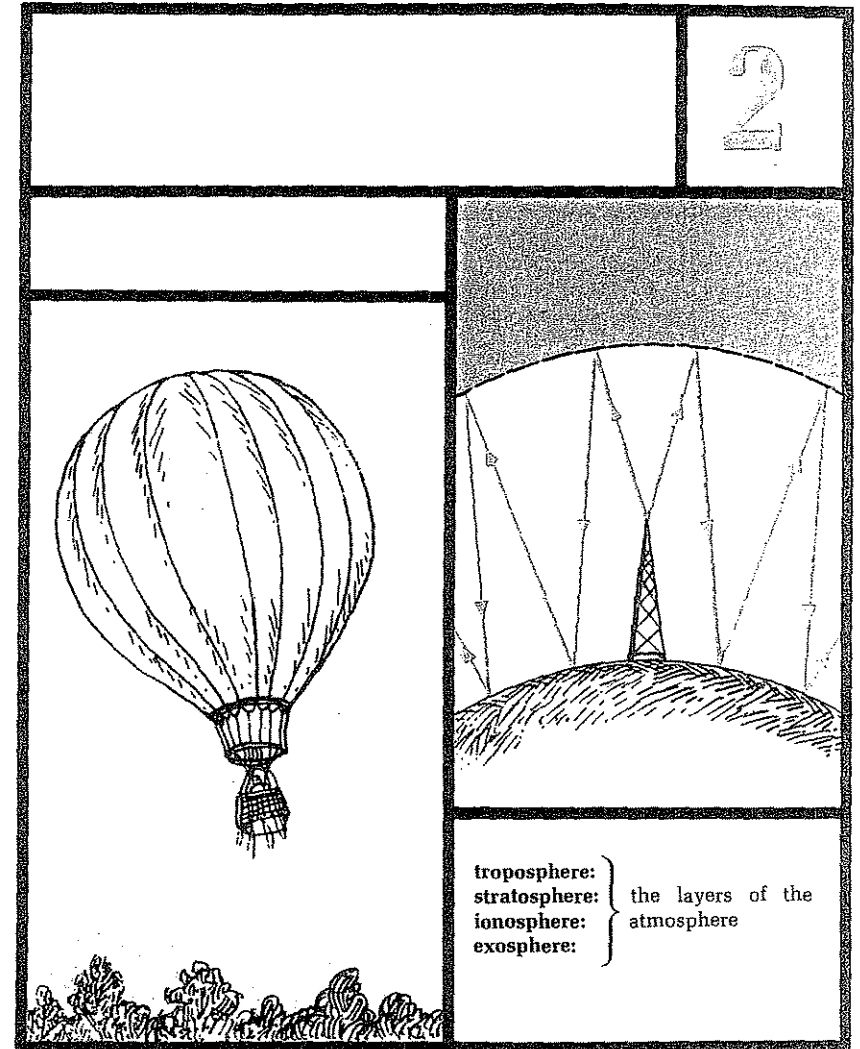
- | | |
|------------------------|--------------------------|
| 1. home chimneys _____ | 5. factories _____ |
| 2. automobiles _____ | 6. airplanes _____ |
| 3. buses _____ | 7. burning garbage _____ |
| 4. motorcycles _____ | 8. burning leaves _____ |

CITY, SUBURBS, OR COUNTRY?

Some parts of our nation are cities. Some parts are suburbs. Still other parts are country areas.

- Where would you expect to find the most air pollution? _____
Why? _____
- Where would you expect to find the least air pollution? _____
Why? _____
- How does air pollution spread from one place to another? _____

WHAT DO WE CALL THE LAYERS OF THE ATMOSPHERE?



AIM What do we call the layers 2 of the atmosphere?

Wood floats on water because wood is lighter than water. A rock sinks because it is heavier than water. A balloon filled with helium floats away because helium is lighter than air.

The atmosphere has four main layers. They are the troposphere [TROPE us feer], the stratosphere [STRAT uh sfee], the ionosphere [eye ON us feer], and the exosphere [EK so sfee].

TROPOSPHERE The troposphere is the lowest layer of the atmosphere. We live in the troposphere. It is the heaviest layer.

Most weather occurs in the troposphere. The higher you go in the troposphere, the colder it gets.

STRATOSPHERE The stratosphere is above the troposphere.

It is very cold in the lower stratosphere. The higher you go in the stratosphere, the less wind there is.

IONOSPHERE The ionosphere is above the stratosphere.

Radio waves bounce off the ionosphere. Conditions in the ionosphere allow us to send radio messages around the world.

EXOSPHERE The exosphere is the uppermost layer of the atmosphere. There are few air molecules there.

In the exosphere, there is dangerous radiation that comes from space.

FILL IN THE BLANKS Figure A shows the layers of the atmosphere. Study this chart. Then answer the questions.

- Name the four layers of the atmosphere. Start with the lowest layer and name them in order.
_____, _____, _____, _____.
- Is the troposphere the same height everywhere? _____
 - Where is the troposphere the highest? _____
 - About how high is it? _____
- Where is the troposphere the lowest? _____
 - About how high is it? _____

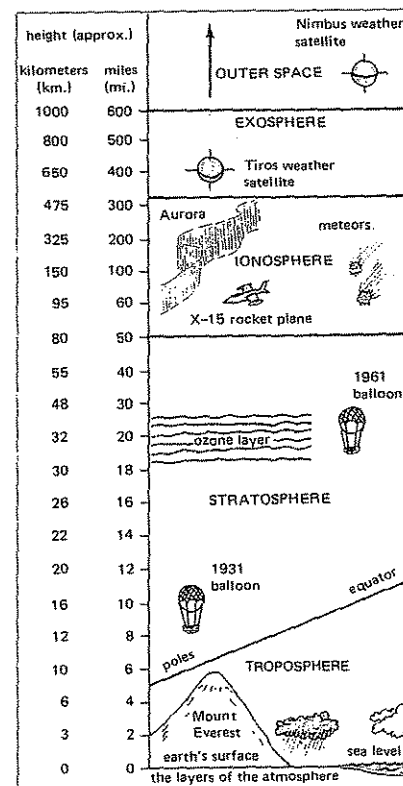


Figure A

- Which layer
 - has the most air? _____
 - has the least air? _____
- About how high is Mount Everest? _____
- In which layer does most weather take place? _____
- In which layer is the Tiros weather satellite? _____
 - About how high is it? _____
- In which layer is the Nimbus weather satellite? _____

9. About how high

- did the X-15 rocket plane go? _____
- did the 1931 manned balloon go? _____
- did the 1961 manned balloon go? (official world record) _____
(Measure the height from the center of each.)

10. Meteors start to burn in the atmosphere and sometimes fall to earth. In which layer do they start to burn? _____

NORTHERN LIGHTS



Figure B

Figure B shows an aurora (uh ROAR uh). Changes in the upper atmosphere cause the sky to light up near the earth's poles. These lights can be seen from Canada and the northern United States where they are called the northern lights. Similar lights are seen near the South Pole.

- In which layer is the aurora? _____
- At about what height does the aurora start? _____
- At about what height does it end? _____
- About how thick is the aurora? _____
- The _____ starts at the upper part of the aurora.

ULTRAVIOLET AND THE OZONE LAYER

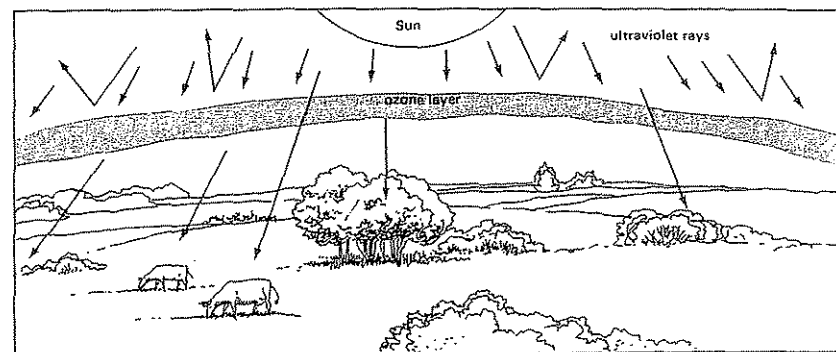


Figure C

In addition to the light that we can see, the sun gives off ultraviolet rays. Ultraviolet rays are invisible. We need these invisible rays—but only in small amounts. Too much ultraviolet can be dangerous.

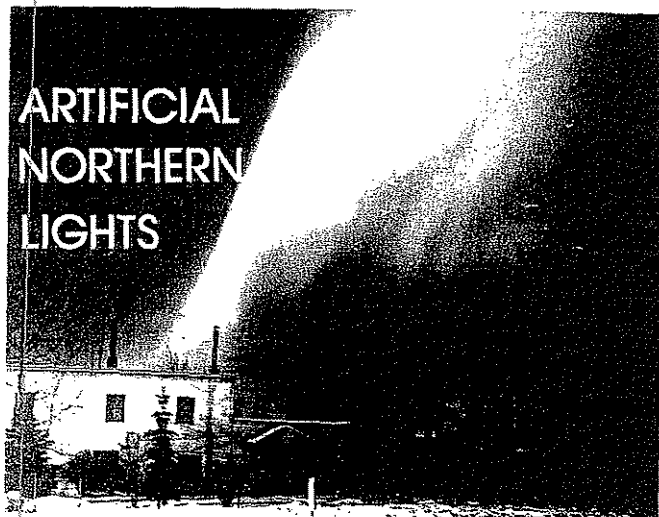
A special layer of gas lets just the right amount of ultraviolet light pass through to the earth. The gas layer is made of ozone, a form of oxygen. The ozone layer acts like a filter.

- In which layer is the ozone found? _____
- At about what height does the ozone begin? _____
- At about what height does the ozone end? _____
- About how thick is the ozone layer? _____

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|----------------------------------|--|
| 1. _____ troposphere | a) highest atmosphere layer |
| 2. _____ exosphere | b) important for long-distance radio signals |
| 3. _____ ionosphere | c) filters out ultraviolet rays |
| 4. _____ gases of the atmosphere | d) lowest atmosphere layer |
| 5. _____ ozone | e) separate according to weight |

KEEPING UP WITH SCIENCE



ARTIFICIAL NORTHERN LIGHTS

The northern lights, or *aurora borealis*, can be one of nature's great spectacles. It is made up of sheets of flickering lights. Sometimes the lights are colored.

The northern lights are caused by charged particles (protons and electrons) that are shot out from the sun in great bursts. As they approach the earth, they are attracted by the planet's magnetic field. When these protons and electrons enter the atmosphere, they collide with the gas molecules that make up the atmosphere. Each molecule becomes "excited" and gives off a flash of light.

Is there such a thing as artificial northern lights? Recently, American scientists were working in a research station in Antarctica. As part of their work, they sent extra-long (10-miles long) radio waves far

out into space. The waves of electrons finally plunged earthward near Quebec City, Canada. These electrons probably created a weak display of northern lights. But they were too dim to be seen by the naked eye.

In Antarctica, an aurora would also have been created at the same time. Evidence of what happened there has come from rockets and balloons. They were sent aloft at the research station in Antarctica with instruments to record the electron shower, or aurora.

Why was this experiment carried out? Long-range radio communication is important. But certain conditions in the atmosphere disrupt these communications. Scientists hope studies of this kind will help us understand these disruptive conditions—and even make use of them.

WHAT ARE SOME PROPERTIES OF AIR?

3

matter: anything that has weight and takes up space; any solid, liquid, or gas

atom: smallest part of matter

molecule: matter that has two or more atoms

property: something special about matter that helps us identify it

AIM 3 | What are some properties of air?

What is this book made of—metal or paper? It is made of paper, of course. But how do you know? You know from its properties.

Properties are special things about matter. Properties help us to tell one kind of matter from another.

There are many kinds of properties. Some common properties are state, weight, hardness, color, and odor.

Air has certain properties. Let's examine three properties of air.

AIR IS INVISIBLE

The natural gases of the air have no color. You cannot see them.

AIR HAS WEIGHT

Air is matter. It is made up of atoms and molecules. Atoms and molecules have weight. This means that air has weight.

Figure B shows how you can prove that air has weight.

AIR TAKES UP SPACE

Anything that has weight also takes up space. Since air has weight, air *also* takes up space. The experiment with Figure C shows how you can prove that air takes up space.

So far, you have learned that:

AIR { is invisible
has weight
takes up space

You will learn more about air in the next Aims.

SOME PROPERTIES OF AIR

A. SEEING IS BELIEVING

Look at Figure A. Then answer the questions.

1. What is inside the glass?

2. What property of air is shown here?



Figure A

B. PROVING THAT AIR HAS WEIGHT

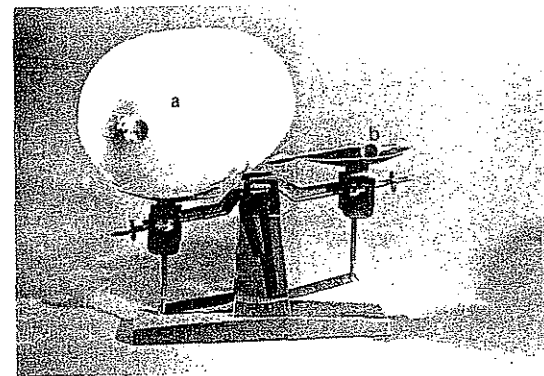


Figure B

Without air in them, both balloons in Figure B weigh the same.

1. Which balloon now weighs more, A or B? _____

2. Balloon _____ is heavier because it has _____ in it.

3. What property of air does this show? _____

C. PROVING THAT AIR TAKES UP SPACE



Figure C

What To Do

1. Crumple a dry piece of paper. Stuff it into a glass.
2. Turn the glass upside down. Push it straight down into a large jar or sink filled with water. Keep it there for 30 seconds.
3. Lift the glass out of the water straight up.
4. Take out the paper and feel it.

What You Learned

1. The paper became wet, stayed dry
2. The water did, did not get into the glass.
3. What stopped the water from going into the glass? _____
4. What must happen for water to get into the glass? _____
5. Can two things take up the same space at the same time? _____
6. What property of air does this experiment show? _____

COMPLETING SENTENCES

Complete the sentences with the choices below.

molecules
nitrogen
properties
air takes up space
invisible

space
water vapor
gases
oxygen

air has weight
see
air is invisible
weight

1. Air is a mixture of _____.
2. We cannot _____ the gases of the air.
3. The word that means "not capable of being seen" is _____.
4. Air is made up of atoms and _____.
5. Atoms and molecules have _____ and take up _____.
6. Special things that help us identify matter are called _____.
7. This lesson discussed three properties of air. They are: _____.
8. The gas that makes up most of the air is _____.
9. The gas that all living things need is _____.
10. Water in gas form is called _____.

TRUE OR FALSE

Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

1. _____ You can see the gases of the air.
2. _____ Dust is invisible.
3. _____ Most of the time we do not see dust because dust is large.
4. _____ Air is made up of atoms and molecules.
5. _____ Atoms and molecules have no weight.
6. _____ Atoms and molecules take up space.
7. _____ Air has weight.
8. _____ Air takes up space.
9. _____ Air has weight and takes up space because it is invisible.
10. _____ An "empty" bottle has nothing in it.

REACHING OUT

A balloon filled with helium gas floats away.

1. Does this mean that helium has no weight? _____

2. What does it mean? _____

WORD SEARCH

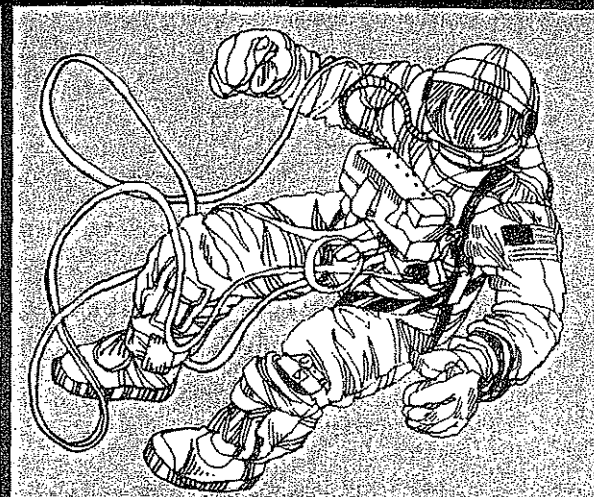
The words in this list are hidden in the groups of letters. Try to find each word. When you find it, circle the word. The spelling may go backwards or forwards in any direction: up-and-down, across, or diagonally.

OXYGEN
DUST
TROPOSPHERE
IONOSPHERE
AURORA
EXOSPHERE
NITROGEN
POLLUTION
STRATOSPHERE
OZONE
ULTRAVIOLET

T	A	R	U	A	N	Y	G	X	T	Z	O
E	E	N	O	I	T	U	L	L	O	P	E
L	D	R	B	O	X	Y	G	E	N	R	N
O	L	U	E	M	I	L	L	Y	E	L	I
I	P	O	S	H	O	E	T	H	N	E	T
V	T	L	I	T	P	N	P	X	O	S	R
A	E	R	E	H	P	S	O	X	E	L	O
R	G	L	Y	U	O	N	O	I	N	I	G
T	A	S	H	P	G	R	T	N	O	E	E
L	R	P	O	V	E	N	O	Z	O	Z	N
U	Y	R	I	A	R	O	R	U	A	I	O
S	T	R	A	T	O	S	P	H	E	R	E

DOES AIR HAVE PRESSURE?

4



gravity: the force that pulls things downward

air pressure: the weight of air pressing on a surface

AIM | Does air have pressure?

4

What keeps you from floating into space?

There is a force called gravity that pulls things towards the earth. This downward force keeps you from floating away. Gravity also keeps the gases of the air from escaping into space.

The pull of gravity is stronger the closer you are to the earth's center. The pull becomes weaker the farther you go from the earth's center.

Most molecules of the air are held close to the earth's surface where gravity is strong. There are fewer and fewer molecules the higher up you go.

The atmosphere reaches up almost 1000 kilometers (600 miles). This means that there are 1000 kilometers of molecules piled on top of one another. A column of air this high is quite heavy. In fact, at sea level a column of air on one square inch weighs about 15 pounds (1 kilogram per 1 square centimeter). THE WEIGHT OF ALL THESE GAS MOLECULES IS CALLED AIR PRESSURE.

The pull of gravity results in more gas molecules at sea level than higher up. Therefore, the air pressure is greater closer to the ground. The higher you go above sea level, the lesser the air pressure. The lower you go below sea level, the greater the air pressure.

How many square inches of surface area does your body have? Try to figure it out sometime. On every square inch of your body there are 15 pounds of air pressure. This could add up to over 10 tons of pressure on your body.

Why doesn't the air crush you? Air doesn't press downward only. AIR PRESSES IN ALL DIRECTIONS.

There is air inside your body, too. This air presses outward with the same force as the air that is pressing inward. This keeps you from being crushed.

GRAVITY AND AIR

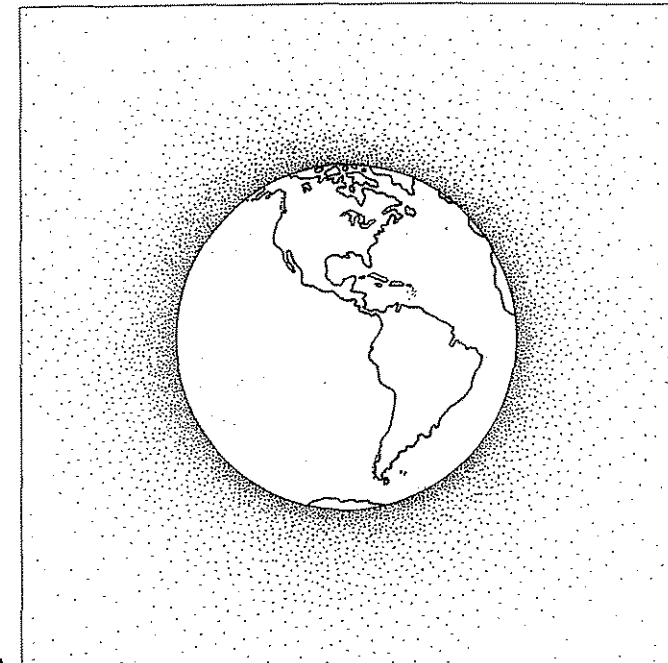


Figure A

1. The force that holds the air close to the earth is called _____.
2. Gravity is _____ an upward, a downward force.
3. Gravity is strongest _____ on the earth's surface, high up.
4. Gravity is weakest _____ on the earth's surface, high up.
5. There is more air where gravity is _____ strongest, weakest.
6. There is less air where gravity is _____ strongest, weakest.
7. Most of our air is _____ close to the ground, high up.
8. There is less air _____ close to the ground, high up.
9. About how high does the atmosphere reach? _____

AIR PRESSURE AND WEIGHT

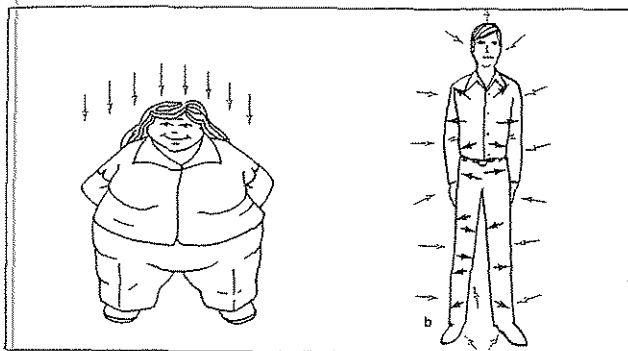


Figure B

Air does not press like this.

Air presses like this.

Look at Figure B.

1. Air presses _____
only downward, only upward, in all directions

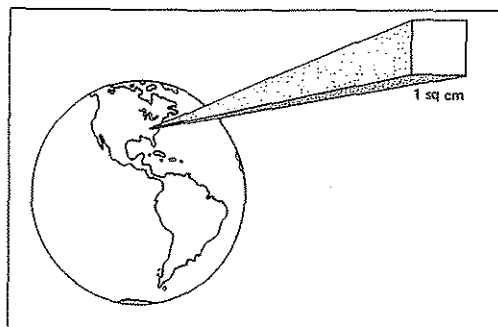


Figure C

At sea level, a column of air resting on one square centimeter (1 sq cm) weighs 1 kilogram (kg).

2. What gives air its weight? _____
3. Which layer of the atmosphere gives most of this weight? _____
(Look back to Aim 2 if you have to.)
4. The air pressure at sea level is _____ kilogram per square
_____.

SEA LEVEL, MOUNTAIN, AND VALLEY

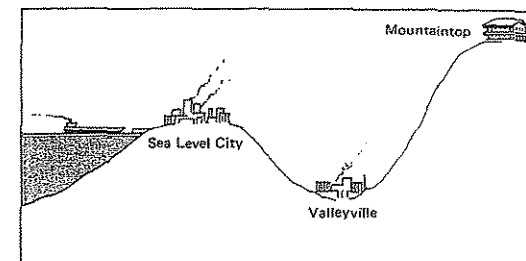


Figure D

Answer each of the following questions with Sea Level City, Valleyville, or Mountaintop.

1. Air pressure is greatest at _____.
2. Air pressure is weakest at _____.
3. Air pressure is 1 kg per sq cm at _____.
4. Air pressure is greater than 1 kg per sq cm at _____.
5. Air pressure is less than 1 kg per sq cm at _____.

COMPLETING SENTENCES Complete the sentences with the choices below.

mountain	close	gases
surface	1 kg per sq cm	valley
1000 kilometers	gravity	weaker
downward	less	

1. The force that holds things down is called _____.
2. Gravity pulls only in a _____ direction.
3. Gravity is strongest close to the earth's _____.
4. As you go higher, gravity becomes _____.
5. Air is a mixture of _____.
6. Most air is _____ to the earth's surface.
7. The higher you go, the _____ air there is.
8. The atmosphere reaches up about _____ in space.
9. At sea level, air presses with a force of about _____.
10. Air pressure is usually greater in a _____ than it is on a
_____.

EXPERIMENTING WITH AIR PRESSURE

PURPOSE: To show that air has pressure and that it presses in all directions.



What You Need glass tumbler
water
thin cardboard

PART I. How To Do The Experiment

1. Fill the tumbler (to the brim) with water.
2. Place the cardboard on top.
3. Hold a finger on the cardboard. Turn the glass upside down and take your finger away.

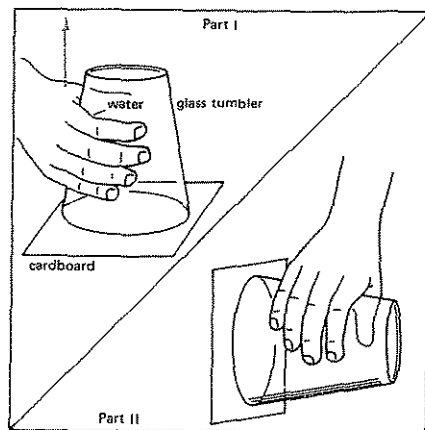


Figure E

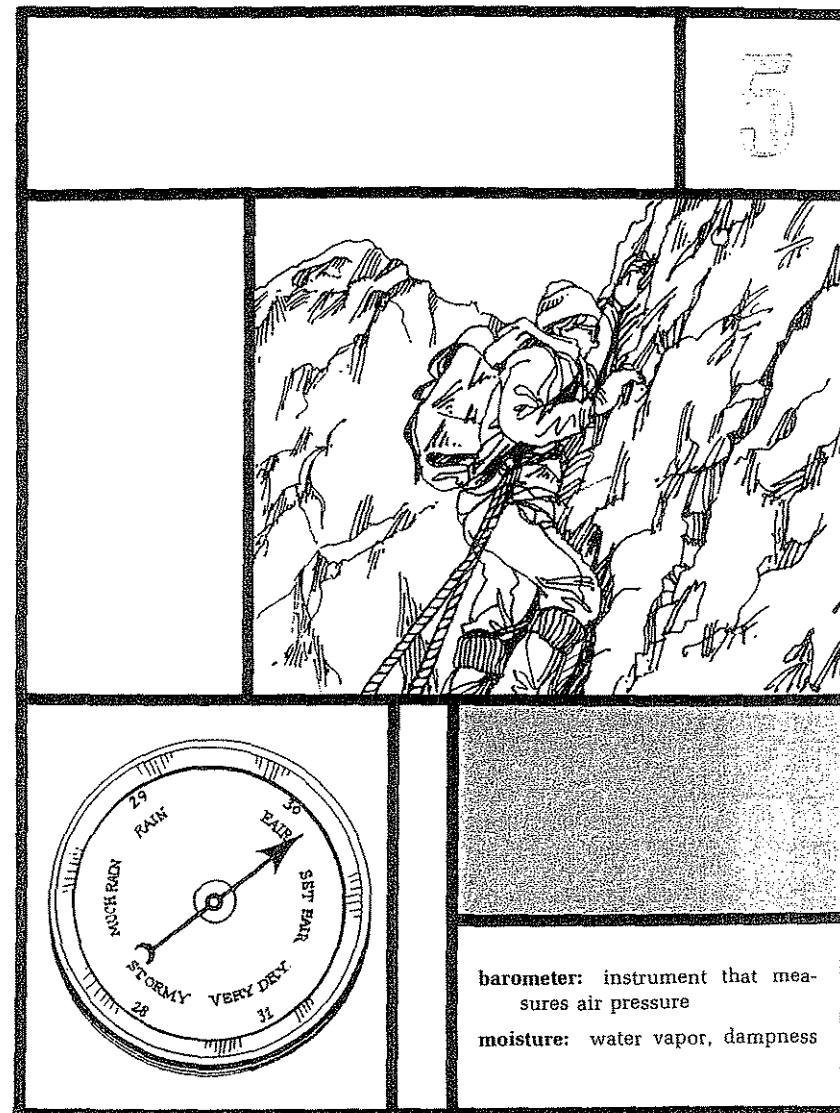
What I Saw: What I Learned

1. The cardboard _____ fell down, stayed on the glass
2. The water _____ spilled out, stayed in the glass
3. _____ kept the cardboard from falling.
Air pressure, Water pressure
4. _____ air pressure kept the cardboard from falling.
Upward, Downward
5. The upward air pressure on the cardboard was _____ than the downward water pressure.
greater, less

PART II. Now slowly turn the glass sideways. Then slowly turn it in *all* directions.

1. The cardboard _____ fell down, stayed on the glass
2. The water _____ spilled out, stayed in the glass
3. _____ kept the cardboard from falling down.
Air pressure, Water pressure
4. We have shown that air presses _____
only up, only down, only to the sides, in every direction

WHAT MAKES AIR PRESSURE CHANGE?



barometer: instrument that measures air pressure

moisture: water vapor, dampness

AIM | What makes air pressure 5 | change?

Where is air pressure higher, Mount Everest or Death Valley? Death Valley is below sea level. It has higher air pressure.

But, air pressure can change even without going from mountains to valleys.

Two other things can change air pressure. They are temperature and the amount of water vapor in the air.

TEMPERATURE Heat makes air molecules move faster. As they move faster, the molecules spread farther apart. A container of warm air has fewer molecules in it than an equal container of cool air.

Fewer molecules mean less weight. And less weight means less pressure.

WARM AIR WEIGHS LESS THAN COOL AIR.

WARM AIR HAS LESS PRESSURE THAN COOL AIR.

AMOUNT OF WATER VAPOR Water vapor weighs less than most of the other gases of the air.

Each molecule of water vapor that goes into the air pushes aside some other air molecule.

Usually, a heavier molecule is pushed aside. This makes the air lighter.

MOIST AIR WEIGHS LESS THAN DRY AIR.

MOIST AIR HAS LESS PRESSURE THAN DRY AIR.

LET'S REVIEW

Review what you learned about air pressure in Aim 4. Look at Figure A. Then answer the questions. Write the correct letter in the blank spaces.

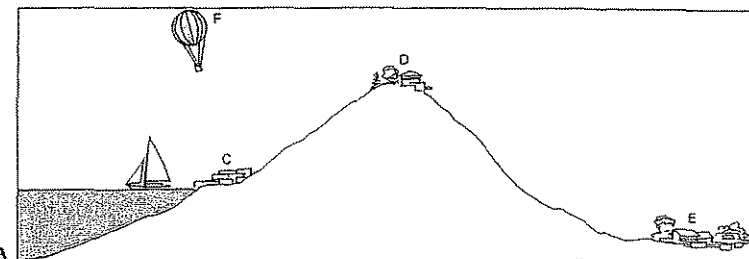


Figure A

1. Air molecules are closest together at _____.
2. Air molecules are farthest apart at _____.
3. Air pressure is greatest at _____.
4. Air pressure is least at _____.

TEMPERATURE CHANGES AIR PRESSURE

Study Figures B and C. Then answer the questions with B or C.

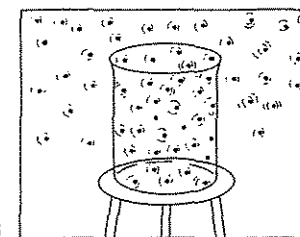


Figure B

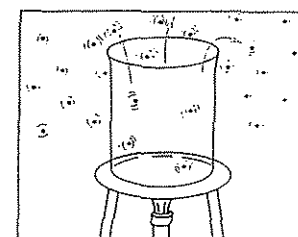


Figure C

1. Which beaker has the warmer air? _____
2. Which beaker has the cooler air? _____
3. Which beaker has more air molecules? _____
4. Which beaker has fewer air molecules? _____
5. Air is lighter in beaker _____.
6. Air is heavier in beaker _____.
7. Air pressure is greater in beaker _____.
8. Air pressure is less in beaker _____.

MOISTURE CHANGES AIR PRESSURE. TOO

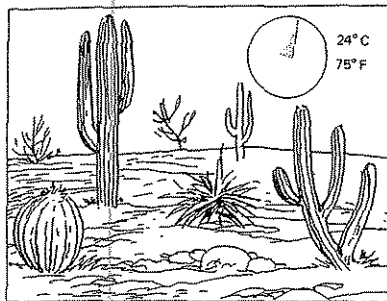


Figure D

Sandy Desert



Figure E

Ferny Rain Forest

These two places are both at sea level.

1. The air in Figure _____ has a lot of water vapor.
2. The air in Figure _____ has very little water vapor.
3. Which air is heavier? _____
4. Which air is lighter? _____
5. Air pressure is greater in _____.
6. Air pressure is weaker in _____.

ABOUT BAROMETERS

Air pressure can be measured with a barometer. A simple barometer can be made like this: Pour mercury into a bowl.

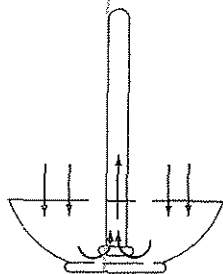


Figure F

Fill a glass tube that is at least 85 cm (31 inches) long with mercury. Hold a finger over the open end of the tube. Turn the tube upside down. Then put its open end (where your finger is) into the mercury of the bowl.

The level of the mercury column in the tube will drop a little. The level will drop until there is a column of mercury 76 cm (about 30 inches) above the surface of mercury in the bowl.

The pressure of the air presses down on the mercury in the bowl. This pressure supports, or holds up, the weight of the mercury in the tube. When the air pressure increases, the mercury in the tube rises a little. When the air pressure decreases, the mercury in the tube falls a little.

Another barometer is the aneroid [AN uh roid] barometer.

This is the barometer that is commonly used to measure air pressure.

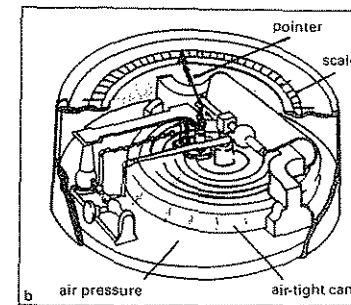
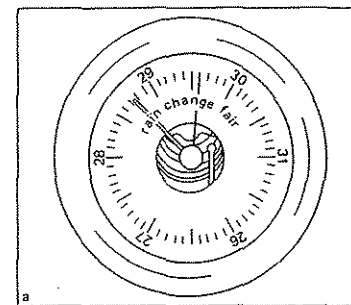


Figure G

The aneroid barometer is made of a small drum that has almost no air in it. The drum is "squeezed" when the air pressure is high. It gets bigger when the air pressure is low.

A spring connects the small drum to a scale that can be read.

COMPLETING SENTENCES Complete the sentences with the choices below. One of these may be used twice.

molecules	how high up you are	presses
less	atoms	weight
temperature	barometer	moist
gases	amount of water vapor in the air	higher

1. The atmosphere is a mixture of _____.
2. Gases are made up of _____ and _____.
3. Atoms and molecules have _____.
4. Anything that has weight also _____ against things.
5. Three things that can change air pressure are: _____, _____ and _____.
6. Air pressure becomes weaker the _____ you go.
7. Usually, warm air presses _____ than cool air.
8. Moist air weighs _____ than dry air.
9. A word that describes air with a lot of water vapor is _____.
10. The instrument that measures air pressure is called a _____.

CHOOSE ONE Choose the correct word to complete each statement. Underline the correct word in each sentence below.

1. Molecules move faster in (warm, cool) air.
2. Air that is warm takes up (more, less) space than cool air.
3. Warm air weighs (more, less) than cool air.
4. Warm air presses (more, less) than cool air.
5. Water vapor is a (liquid, gas).
6. Water vapor molecules weigh (more, less) than most other gases of the air.
7. Moist air is (heavier, lighter) than dry air.
8. Moist air presses (more, less) than dry air.
9. The higher you go, the (more, less) air there is.
10. Air pressure is (greater, less) on a mountain than at sea level.

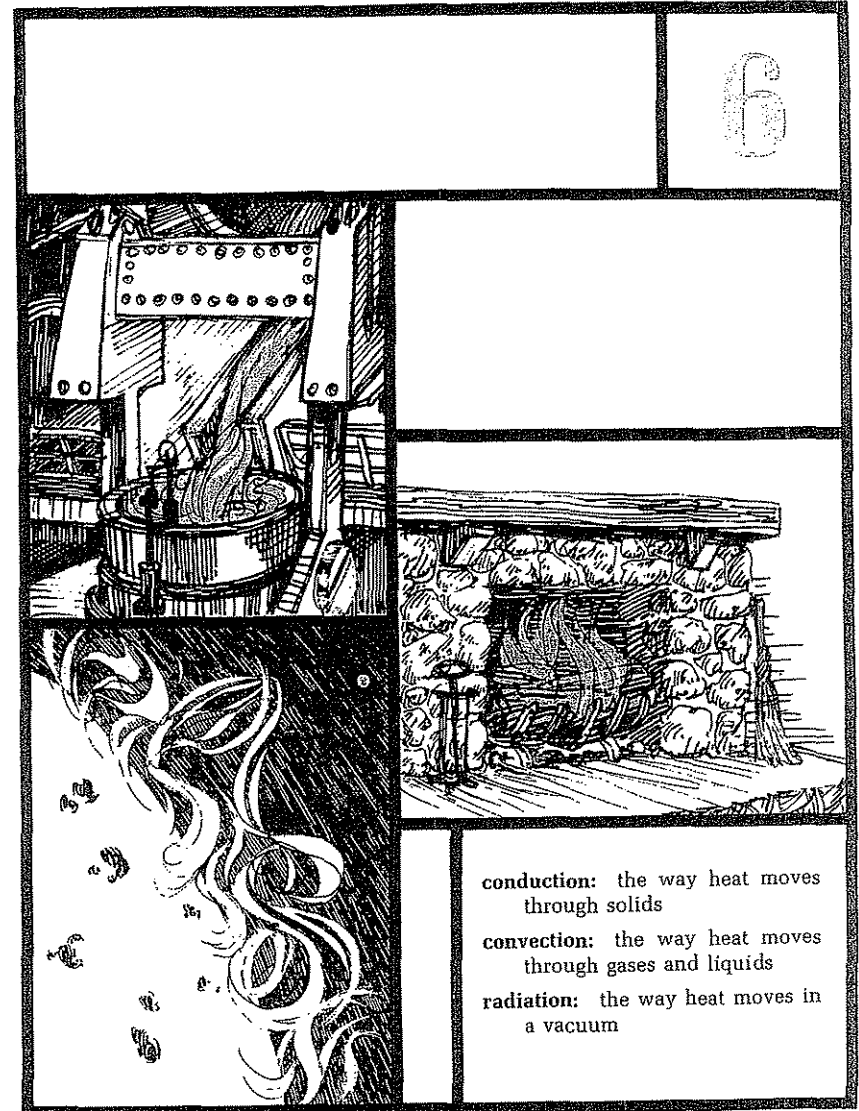
REACHING OUT

1. Why do mountain climbers have trouble breathing on high mountains?

2. Mountain A and Mountain B are the same height. At their tops the temperatures are the same. But Mountain B is covered by very moist air. Which mountain has the greater air pressure? Why?

HOW DOES THE SUN HEAT THE ATMOSPHERE?

6



conduction: the way heat moves through solids
convection: the way heat moves through gases and liquids
radiation: the way heat moves in a vacuum

AIM | How does the sun heat the atmosphere?

Without the sun, there would be no life on earth. Plants need the sun to help them grow. Without plants we would have no food to eat and no oxygen to breathe.

The sun also gives us warmth. The sun heats the atmosphere and all the lands and waters.

Heat moves in three ways—conduction, convection, and radiation.

CONDUCTION Heat moves through solids by conduction. In conduction, vibrating molecules pass on heat from molecule to molecule.

CONVECTION Heat moves through gases and liquids by convection. In convection, heated molecules move away from the heat. Cooler molecules take their place. Then they become heated, too.

RADIATION Conduction and convection need molecules to work. Radiation does not. Radiation is the way heat moves where there are no atoms or molecules.

Now let's trace the sun's energy.

■ The sun is about 150 million kilometers (93 million miles) from Earth. Most of this distance is empty space where there are almost no atoms or molecules. Such an empty space is called a vacuum [VAK yoo um]. Energy from the sun moves through this vacuum by radiation.

■ The sun's energy then hits the atmosphere. The air molecules become heated by convection.

■ The sun's energy finally reaches the land and water on earth. The water becomes heated by convection. The land becomes heated by conduction.

Some of the heat from the land and water reflects (bounces) back into the atmosphere. This warms the atmosphere even more.

CONDUCTION, CONVECTION, AND RADIATION

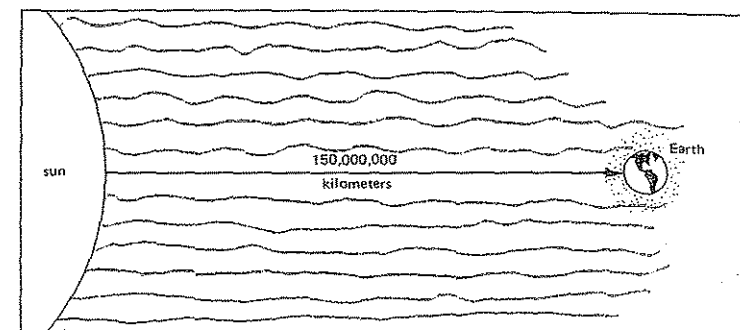


Figure A

1. Most of the distance between the sun and the earth is _____
air, empty space
2. In outer space, there are _____ atoms and molecules.
few, many
3. The sun's energy moves through outer space by _____
conduction, convection, radiation
4. Radiation _____ need atoms and molecules to work.
does, does not

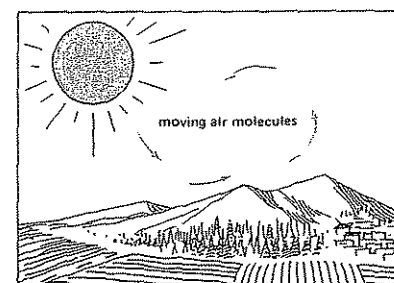


Figure B

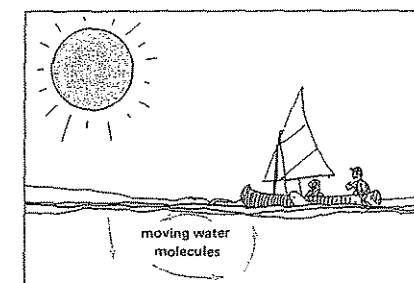


Figure C

5. Heat moves through gases and liquids by _____
conduction, convection, radiation
6. Convection _____ need atoms and molecules to work.
does, does not
7. What are liquids and gases made of? _____
8. Can the atoms and molecules of gases and liquids move from place to place?

9. After atoms and molecules of gases and liquids are heated, they move away from the heat. What takes their place? _____
10. What happens to some of the heat from the oceans, lakes, and streams?
- _____
- _____

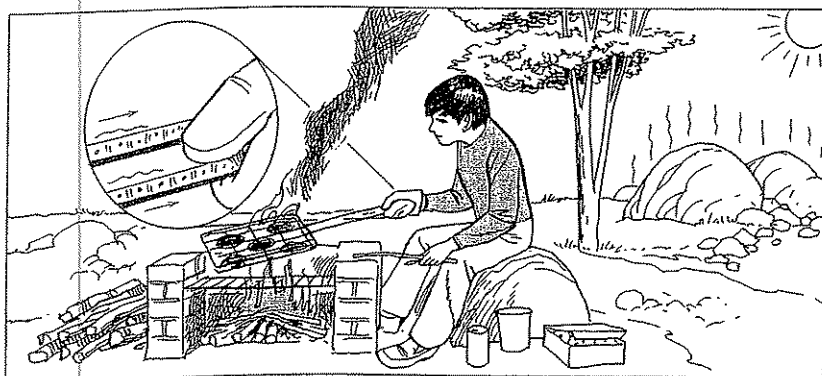


Figure D

11. Heat moves through solids by _____
conduction, convection, radiation
12. Conduction _____ need atoms and molecules to work.
does, does not
13. What are solids made of? _____
14. Can the atoms and molecules of solids move from place to place? _____
15. Explain how heat moves through solids. _____
- _____
16. What happens to some of the heat from the land? _____
- _____
- _____

COMPLETING SENTENCES

Complete the sentences with the choices below. Two terms may be used twice. One term may be used three times. One term may be used four times.

convection
atmosphere
radiation

atoms and molecules
conduction

- The three ways that heat moves from place to place are _____.
- Heat moves through solids by _____.
- Heat moves through liquids and gases by _____.
- Heat moves through empty space by _____.
- In conduction and convection, heat is carried by _____.
- In empty space, there are hardly any _____.
- Our atmosphere is heated by _____.
- Our rocks and soil are heated by _____.
- Our oceans, rivers, and streams are heated by _____.
- Some of the heat from the land and water bounce back into the _____.

MATCHING

Match the two lists. Write the correct letter on the line next to each number.

- | | |
|---------------------|---|
| 1. _____ sun | a) the way heat moves through empty space |
| 2. _____ conduction | b) mixture of gases |
| 3. _____ convection | c) warms our entire planet |
| 4. _____ radiation | d) the way heat moves through gases and liquids |
| 5. _____ atmosphere | e) the way heat moves through solids |

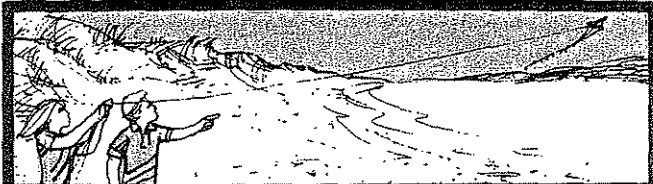


TRUE OR FALSE Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

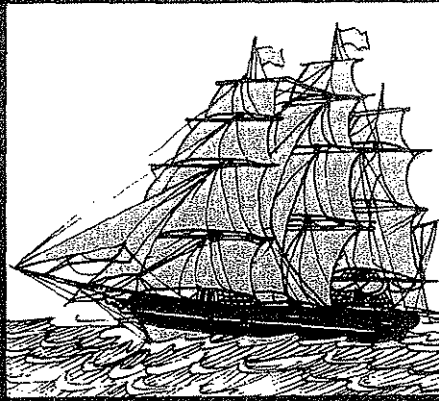
1. _____ Heat stays in one place.
2. _____ Heat moves only where there are atoms and molecules.
3. _____ Heat moves in three different ways.
4. _____ In solids, heat moves by convection.
5. _____ In gases and liquids, heat moves by convection.
6. _____ Conduction and convection need atoms and molecules.
7. _____ In empty space heat moves by radiation.
8. _____ There are many atoms and molecules in outer space.
9. _____ The earth gets its heat from the sun.
10. _____ Heat can be reflected.

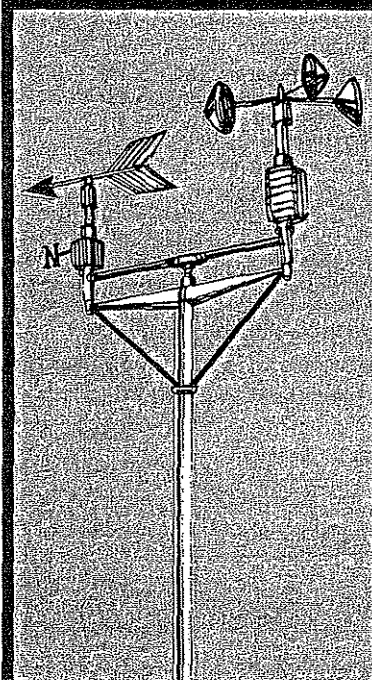
REACHING OUT In what simple way can you show that the earth bounces some heat back into the atmosphere? (You need no instruments to do this—only your hand.)

WHAT IS A WIND?



7





planetary wind: a wind that blows across the entire planet

local wind: a wind that blows in a small area

anemometer: an instrument that measures wind speed

wind vane: an instrument that shows wind direction

AIM | What is a wind?

7

You cannot see wind. But you know it's there. You can feel it pressing against your body. You see tree branches bend when it blows. A gentle wind makes you feel fresh. A strong wind can blow you down.

What is this invisible force we call wind?

A wind is air that is moving parallel to the ground. (Air that moves up or down is not called wind.)

There are two main groups of winds. They are planetary winds and local winds.

PLANETARY WINDS move across our entire planet. They cover very large areas.

Most of the time a planetary wind blows at the same speed and in the same direction. Some planetary winds blow high in the atmosphere. You cannot feel them on the ground.

LOCAL WINDS move across small areas. They change direction and speed very often. Local winds blow low in the atmosphere. You can always feel them on the ground.

Every wind has speed and direction.

■ An anemometer [an uh MOM uh tur] measures how fast a wind blows.

■ A wind vane tells us from which direction a wind blows.

Do you want to know what causes winds? You will find out in the next Aim.

ABOUT WIND

Look at Figure A. The arrows show the directions of the main planetary winds.

1. Do they all blow in the same direction? _____

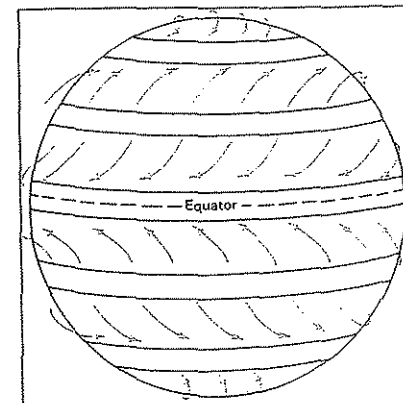


Figure A

The trade winds carried Columbus and his ships across the Atlantic ocean. The trade winds are planetary winds.

2. Why were these more helpful than local winds? _____

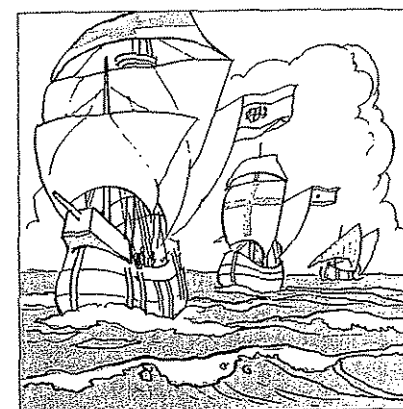


Figure B

Figure C shows an anemometer.

3. What does an anemometer measure? _____

A wind makes the anemometer's cups turn.

4. The stronger the wind, the _____ the cups turn.
slower, faster

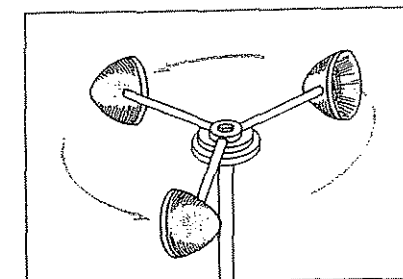


Figure C

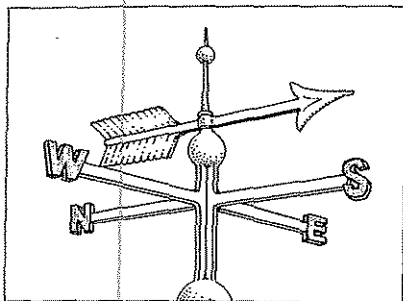


Figure D

Figure D shows a wind vane.

5. Where is the wind coming from?

COMPLETING SENTENCES

Complete the sentences with the choices below. Four of these may be used twice.

anemometer
planetary
speed
parallel to the ground

air
high
wind vane
ground

direction
always
local

1. A wind is _____ that is moving _____.
2. The two main groups of winds are _____ winds and _____ winds.
3. Winds that move across the entire planet are called _____ winds.
4. Some planetary winds blow _____ in the atmosphere.
5. You cannot feel some planetary winds on the _____.
6. A planetary wind usually blows at the same _____ and _____.
7. Winds that move across small parts of the earth are called _____ winds.
8. Local winds can _____ be felt on the ground.
9. Local winds often change _____ and _____.
10. An _____ measures wind speed; a _____ shows wind direction.

PLANETARY WIND OR LOCAL WIND?

Put a check (✓) in the proper box.

		Planetary Wind	Local Wind
1.	Covers small area		
2.	Often changes speed and direction		
3.	Covers large area		
4.	Always felt on the ground		
5.	Can be high above the ground		
6.	Speed and direction stays the same		

WHICH ARE WINDS?

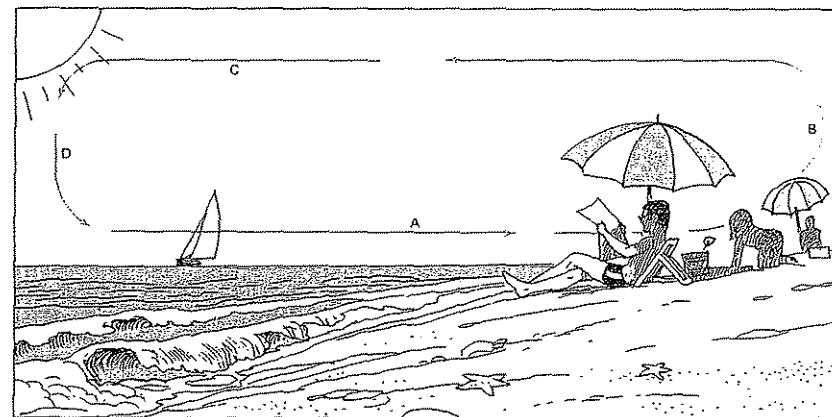


Figure E

A, B, C, and D stand for moving air.

1. Which ones move parallel to the ground? _____
2. Which ones do not move parallel to the ground? _____
3. Which ones are winds? _____
4. Which ones are not winds? _____

MATCHING Match the two lists. Write the correct letter on the line next to each number.

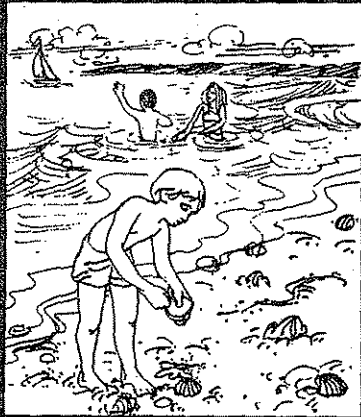
- | | | |
|----------|-----------------|--------------------------------------|
| 1. _____ | wind | a) cover large areas |
| 2. _____ | planetary winds | b) tells wind direction |
| 3. _____ | local winds | c) cover small areas |
| 4. _____ | wind vane | d) measures wind speed |
| 5. _____ | anemometer | e) air moving parallel to the ground |

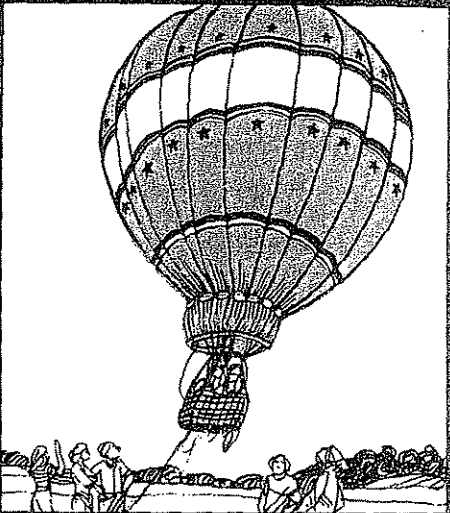
TRUE OR FALSE Write T on the line next to the number if the sentence is true. Write F if the sentence is false.

1. _____ You need air to have a wind.
2. _____ The moon has winds.
3. _____ Air that moves up or down is a wind.
4. _____ There is only one kind of wind.
5. _____ Planetary winds cover large areas.
6. _____ All planetary winds blow high in the atmosphere.
7. _____ Planetary winds often change speed and direction.
8. _____ Local winds cover small areas.
9. _____ You can always feel a local wind.
10. _____ Local winds often change speed and direction.

WHAT CAUSES WIND?

8



air current: air that is moving up or down

AIM | What causes wind?

3

You have learned that the sun heats our entire planet. You know that heat moves through gases by convection.

When heat moves by convection, the heat is not even. Some places are heated more than others.

Warm air and cool air do not weigh the same. You know that warm air is lighter than cool air. And you know that light air rises.

When warm air rises, other cooler air rushes in to take its place. The air that rushes in moves parallel to the ground. It is this moving air that we call "wind."

Wind is caused by the uneven heating of the earth's surface.

- Uneven heating of the entire planet causes planetary winds.

- Uneven heating of smaller areas causes local winds.

The exercise on the facing page shows how a wind is made.

Air that moves up and down is very important in making winds.

Air that moves up or down is called a current.

STUDYING HOW A WIND IS MADE

Study Figure A carefully. Then choose the correct term to complete each statement. Write your choice in the space.

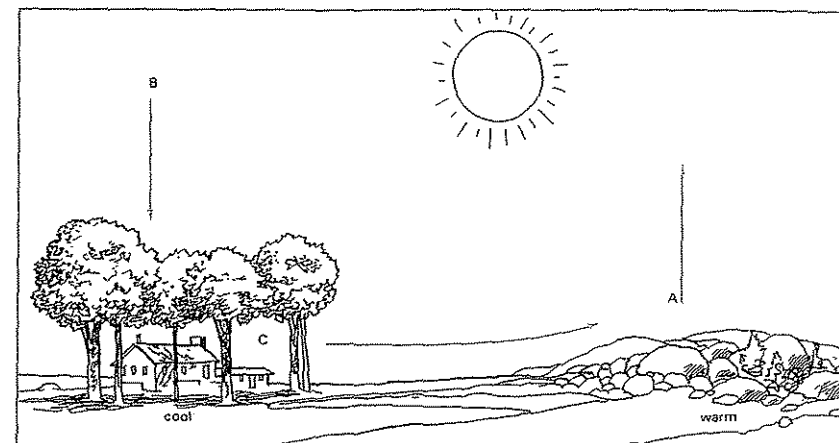


Figure A

- The air at A is _____.
warm, cool
- Warm air is _____ than cool air.
lighter, heavier
- Light air _____.
rises, falls
- The air rising from A is called a _____.
wind, current
- The air at B is _____.
warm, cool
- Cool air is _____ than warm air.
lighter, heavier
- Cool air _____.
rises, falls
- The air moving from B to C is called a _____.
wind, current
- The air moving from C to A is called a _____.
wind, current
- Wind moves from a _____ place to a _____ place.
warm, cool warm, cool

A SPECIAL CHALLENGE!

Now that you know how wind is made, try to answer these questions. Refer to Aim 5 if you have to.

11. Air pressure is greater at _____. Label this spot "High Pressure" on Figure A.

12. Air pressure is less at _____. Label this spot "Low Pressure" on Figure A.

Underline the correct statement.

13. Wind moves from
a) a place of low pressure to a place of high pressure.
b) a place of high pressure to a place of low pressure.

COMPLETING SENTENCES

Complete the sentences with the choices below.

heavier
wind
lighter
drops

local
uneven heating
current

cooler air
planetary
rises

1. Winds are caused by the _____ of the earth.
2. Uneven heating of the entire planet causes _____ winds.
3. Uneven heating of small areas cause _____ winds.
4. Air becomes _____ when it is heated.
5. Warm air _____.
6. Air becomes _____ when it is cooled.
7. Cool air _____.
8. When warm air rises, other _____ moves in to take its place.
9. Air moving parallel to the ground is called a _____.
10. Air moving up or down is called a _____.

MATCHING

Match the two lists. Write the letter next to each number.

- | | |
|----------------------|---------------------------------|
| 1. _____ wind | a) moves up or down |
| 2. _____ current | b) falls |
| 3. _____ heated air | c) move over small areas |
| 4. _____ cooled air | d) moves parallel to the ground |
| 5. _____ local winds | e) rises |

TRUE OR FALSE

Write T on the line next to the number if the sentence is true. Write F if the sentence is false.

1. _____ Warm air weighs less than cool air.
2. _____ Warm air presses more than cool air.
3. _____ Cool air is heavier than warm air.
4. _____ Cool air presses more than warm air.
5. _____ Warm air rises.
6. _____ Cool air rises.
7. _____ Wind moves from a cool place to a warm place.
8. _____ Rising or falling air is called a wind.
9. _____ A wind moves parallel to the ground.
10. _____ All winds move at the same speed.

WORD SCRAMBLE

Unscramble each of the following to form a word or term that you have read in this Aim.

1. RALENTAPY _____
2. DIWN _____
3. RERNUCT _____
4. COLLA _____
5. NEEVUN _____

REACHING
OUT

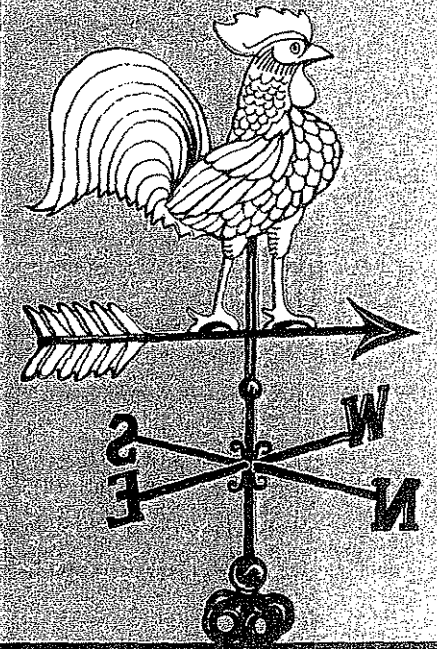
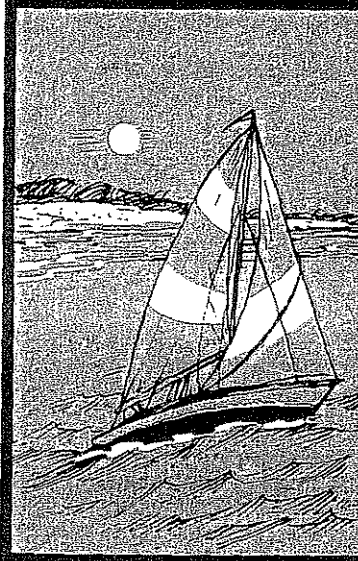
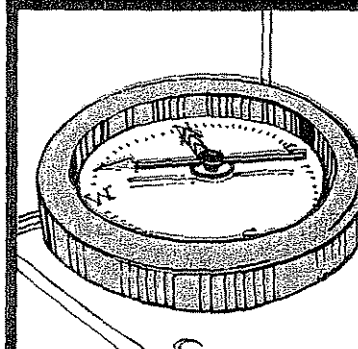
Wind moves from high pressure to low pressure.

What makes some winds stronger than others?



HOW ARE WINDS NAMED?

9



prevailing westerlies: planetary
winds from the west

AIM | How are winds named?

9

What part of the country do you come from? Do you come from the north? Then you are called a northerner. If you come from the south, you are called a southerner.

A name can tell us where a person comes from.

Winds also have names. The name of a wind tells us where the wind comes from. For example, a sea breeze comes from the sea. A valley breeze comes from a valley.

Winds are also named by compass direction. In fact, most winds are named this way.

A compass has four main direction points. They are: north (N), east (E), south (S), and west (W) (Figure A).

The directions between these main points are: northeast (NE), southeast (SE), southwest (SW), and northwest (NW) (Figure B).

Let's study two winds—a north wind and a southwest wind.

A north wind comes from the north. It moves towards the south (Figure C).

A southwest wind blows from the southwest. It heads towards the northeast (Figure D).

The local winds and planetary winds are named this way. In North America, the important planetary winds come from the west. They are called the prevailing westerlies.

Wind direction and wind speed help us to predict weather.

COMPASS DIRECTIONS

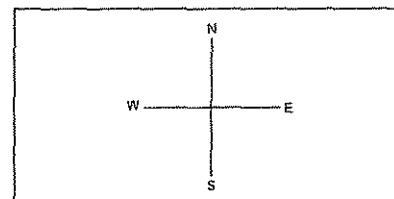


Figure A

The four main points of a compass.

1. N stands for _____.
2. S stands for _____.
3. E stands for _____.
4. W stands for _____.
5. Opposite of north is _____.
6. Opposite of south is _____.
7. Opposite of east is _____.
8. Opposite of west is _____.

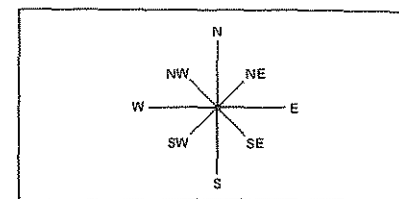


Figure B

The four in-between compass points.

9. NE stands for _____.
10. SE stands for _____.
11. SW stands for _____.
12. NW stands for _____.
13. Opposite of northeast is _____.
14. Opposite of southeast is _____.
15. Opposite of southwest is _____.
16. Opposite of northwest is _____.

WIND DIRECTIONS

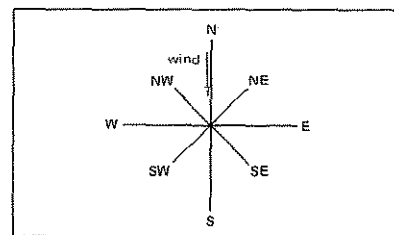


Figure C

1. The wind shown here is coming from the _____.
2. It is heading towards the _____.
3. This wind is a _____ wind.

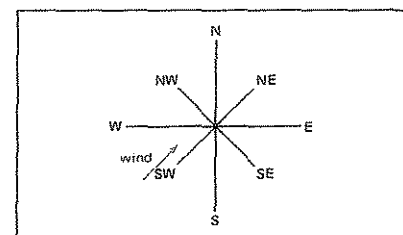


Figure D

4. The wind shown here is coming from the _____.
5. It is moving towards the _____.
6. This wind is a _____ wind.

Underline the answer that shows what you have learned.

7. A wind is named for
 - a) the direction it is going in.
 - b) the direction it is coming from.

COMPLETING SENTENCES Complete the sentences with the choices below. Four of these may be used two times.

north
southwest
current
compass direction

northeast
west
northwest
comes from

east
wind
south
southeast

- Air moving up or down is called a _____.
- Air moving parallel to the ground is called a _____.
- Most winds are named by _____.
- A wind's name is the direction the wind _____.
- The main points of the compass are _____, _____, _____, and _____.
- Four in-between compass points are _____, _____, _____, and _____.
- Opposite of northwest is _____.
- Opposite of west is _____.
- A southwest wind comes from the _____.
- A south wind blows toward the _____.

NAMING WINDS

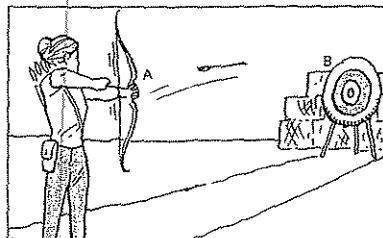


Figure E

- The arrow is moving from _____.

A to B, B to A

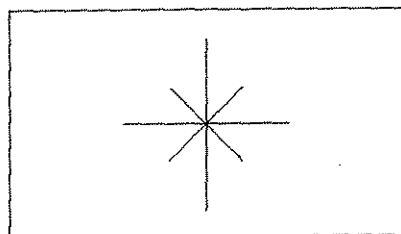


Figure F

- Fill in the eight direction points of this compass. (Try to do it without looking back.)

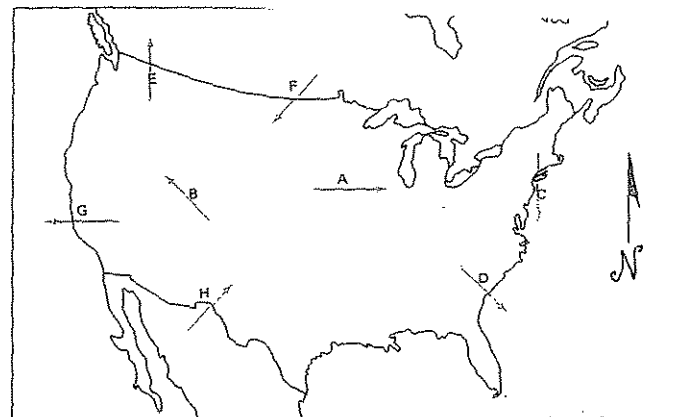


Figure G

The arrows on this map stand for winds. Study each arrow. Then fill in the chart below the map.

Wind	Coming From Which Direction?	Heading Towards Which Direction?	Wind Name
A			
B			
C			
D			
E			
F			
G			
H			

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- _____ compass
 - _____ wind vane
 - _____ N, S, E, W
 - _____ SW wind
 - _____ NE wind
- main compass points
 - heads NE
 - turns with the wind
 - comes from the NE
 - tells direction

KEEPING UP WITH SCIENCE

A CHILL WIND THAT BLOWS NO GOOD

It's a hot day. You are dressed lightly, but you are uncomfortable. An unexpected wind blows up. Suddenly you feel cooler. You spread your arms to catch every bit of this welcome change. Why does a wind have this cooling effect?

Place your hand on your forehead. It feels warm, doesn't it? So does every part of your body. Your body is always losing heat. A wind causes your body to lose heat more quickly. This makes you cooler. The faster a wind blows against your body, the more heat your body loses, and the cooler you feel.

Were you ever outdoors in cold weather when the wind started to blow? Then you know how much colder a wind can make you feel. In the winter it is important to know the air temperature. It is just as important to know what the temperature "feels like" because of the wind. This information helps us decide how to dress for the weather. It may also cause us to change our plans completely.

The effect of wind on the temperature

we feel is called the *wind chill factor*.

In the winter, most weather reports include the *wind-chill temperature*. Weathermen find this temperature in the chart below. It's easy to use.

- The top line lists the air temperature in degrees Fahrenheit.
- The column on the left line lists the wind speeds in miles per hour.

Follow both numbers into the chart. Where the two numbers meet is the *wind chill temperature*.

For example, a temperature of 25°F combined with a wind of 15 miles per hour gives a wind chill temperature of 2°F.

In other words the wind makes 25°F feel like 2°F. Your body would lose heat equal to the heat loss at 2°F.

Do you live in a place that has cold weather part of the year? If you do, then take note of wind-chill temperature reports. They now have special meaning to you.

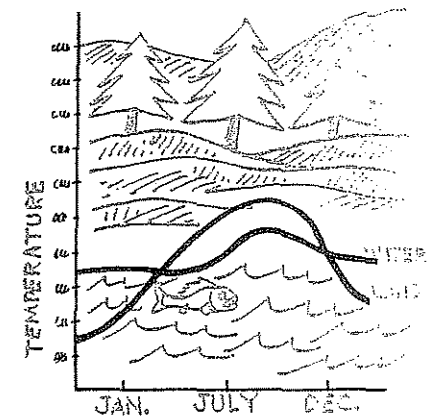
TEMPERATURE IN DEGREES FAHRENHEIT

	35	30	25	20	15	10	5	0	-5	-10
MPH										
5	33	27	21	19	12	7	0	-5	-10	-15
10	22	16	10	3	-3	-9	-15	-22	-27	-34
15	16	9	2	-5	-11	-18	-25	-31	-38	-45
20	12	4	-3	-10	-17	-24	-31	-39	-46	-53
25	8	1	-7	-15	-22	-29	-36	-44	-51	-59
30	6	-2	-10	-18	-25	-33	-41	-49	-56	-64
35	4	-4	-12	-20	-27	-35	-43	-52	-59	-67
40	3	-5	-13	-21	-29	-37	-45	-53	-60	-69
45	2	-6	-14	-22	-30	-38	-46	-54	-62	-70

WIND SPEED

WHICH HEATS FASTER, LAND OR WATER?

10



absorb: to take in
rate: speed per unit time

AIM | Which heats faster, land or 10 | water?

Have you ever walked on the beach on a hot day? The sand can burn your feet. But the water can sure make you shiver! Why is this?

Different materials heat up differently. It takes the ocean water a longer time to warm up than the sand.

When the sun goes down, the sand becomes cool. It loses heat quickly. Meanwhile, the water stays at about the same temperature. If something takes a long time to heat up, it usually takes a long time to cool down. If something heats up quickly, it cools down quickly, too.

Did you ever wonder why many people wear white clothing in the summer? It helps keep them cooler. Different colored materials take in (absorb) heat differently. Usually darker colors absorb more heat than light colors. Darker colors absorb heat faster, too.

Later on in this Aim, you can see for yourself how different materials absorb heat at different rates. Knowing this will help you understand how different parts of the earth are heated.

EXPERIMENTING WITH HEAT

PURPOSE: To find out which heats faster, land or water

What You Need beaker of sand
beaker of water
thermometers (2)
tripods (2)
alcohol burners (2)
blocks of wood (2)
wire screens
ring stand
clamp

How To Do the Experiment

1. Set up the materials. (Figure A shows how to do it.)

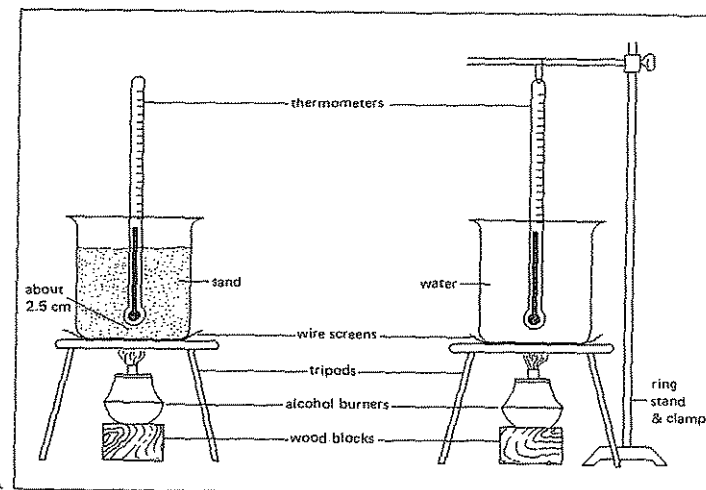


Figure A

2. Read the thermometers before you light the burners. Write the temperatures down on the chart at 0 minutes. (The chart is on page 58.)
3. Light the burners.
4. After one minute, read the thermometers. Write down the temperatures on the chart.
5. Repeat step 4 six times. Write down the temperature at the end of each of the next 6 minutes.
6. Put out the flames.

NOTE: If the sand reaches a temperature of about 68°C (150°F) before 7 minutes, put out both flames. Use the temperature readings up to that point.

Minutes	Temperature—Sand	Temperature—Water
0		
1		
2		
3		
4		
5		
6		
7		

What You Learned

- What was the temperature of the sand before it was heated? _____
 - What was the temperature of the sand after it was heated for 7 minutes?

 - How many degrees hotter did the sand become? _____
- What was the temperature of the water before it was heated? _____
 - What was the temperature of the water after it was heated for 7 minutes?

 - How many degrees hotter did the water become? _____
- This experiment shows that sand heats up _____ than water.
slower, faster
- From this experiment we now can deduce that land heats up _____ than water.
slower, faster

EXPERIMENTING WITH HEAT USING SAND AND SOIL

PURPOSE: To find out which heats up faster, dark or light objects

What You Need flat pan
white sand
dark dry soil
thermometers (2)
light bulb

How To Do the Experiment

(Start this experiment at the beginning of a class period.)

- Set up the materials. Place the white sand on one half of the flat pan and the dark soil on the other half. Put the bulb ends of both thermometers under the surface of the sand and soil. Do not light the light bulb yet. (Figure B shows how to set up the experiment.)

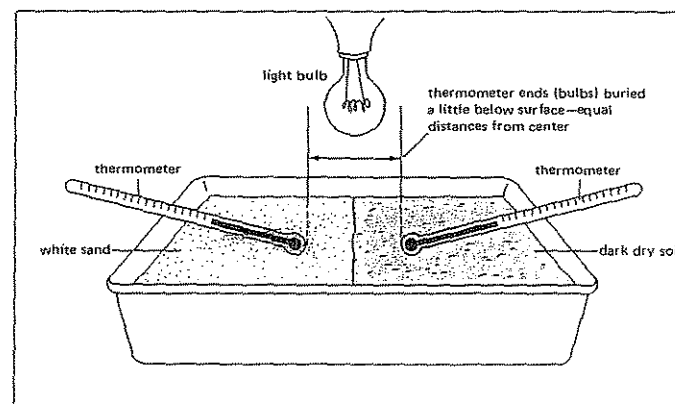


Figure B

- Read the temperatures of both thermometers. Write the temperatures on the chart at 0 minutes.
- Light the light bulb.
- After about 20 minutes, read the thermometers again. Write the temperatures in the chart below.

Minutes	Temperature—Light Sand	Temperature—Dark Soil
0		
20		

What You Learned

1. a) What was the temperature of the white sand before it was heated?

- b) What was its temperature after it was heated for 20 minutes?

- c) How many degrees hotter did the sand become? _____
2. a) What was the temperature of the dark soil before it was heated?

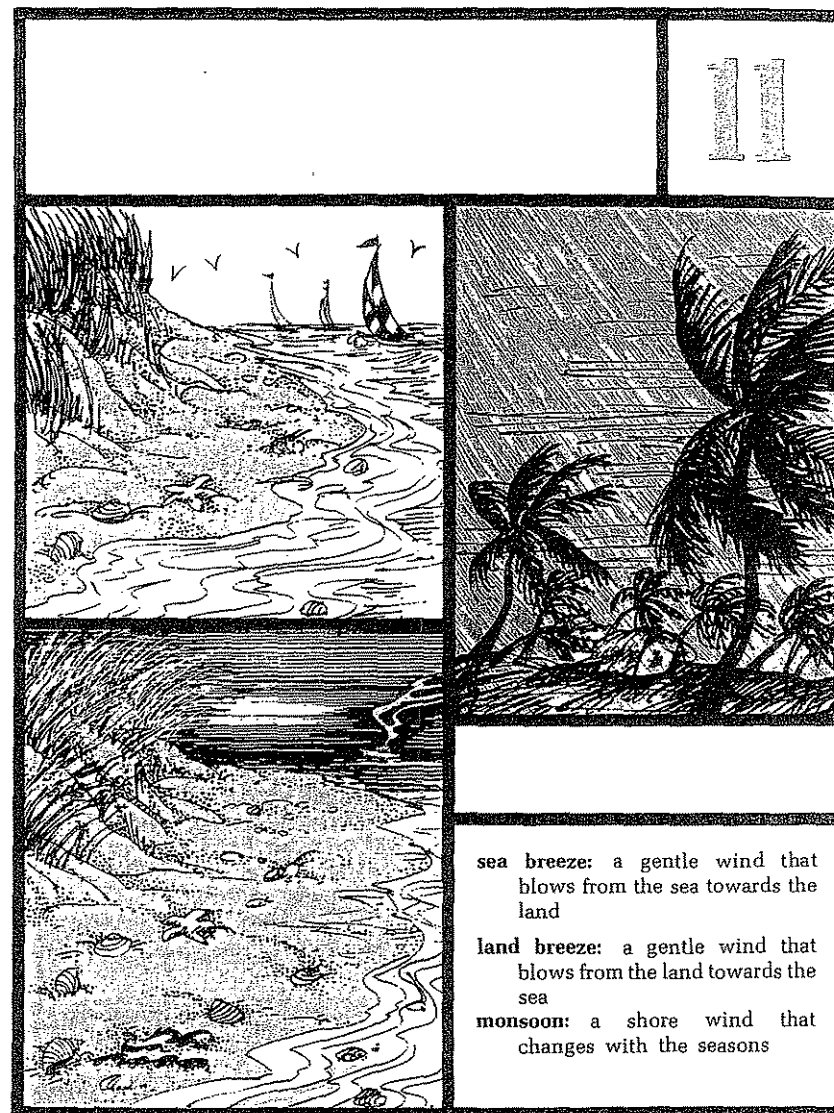
- b) What was its temperature after it was heated for 20 minutes? _____
- c) How many degrees hotter did the dark soil become? _____
3. This experiment shows that dark-colored soil heats up _____ than light-colored sand.
slower, faster
4. In general, dark-colored objects heat up _____ than light-colored objects.
slower, faster

REACHING OUT How would you show that water cools slower than land?
(Hint: Use the same materials as you did in the first experiment.)

60

WHAT ARE SHORE BREEZES?

1



sea breeze: a gentle wind that blows from the sea towards the land

land breeze: a gentle wind that blows from the land towards the sea

monsoon: a shore wind that changes with the seasons

Did you ever visit the seashore? Did you notice that it is usually breezy there?

Shore breezes are special, gentle local winds. There are two kinds of shore breezes—the sea breeze and the land breeze.

A sea breeze moves in from the sea. It heads towards the land. A sea breeze blows during the daytime.

A land breeze moves out from the land. It heads towards the sea. A land breeze blows during the evening hours.

Shore breezes are caused by the uneven heating and cooling of the land and water.

SEA BREEZE During the daytime, the sun heats both the land and the water. But the land heats up faster than the water. Because of this, the air above the land becomes warmer than the air above the water.

The warmer and lighter air above the land rises. Cooler and heavier air that is over the water moves in to take its place.

This air that moves in from the sea and heads towards the land is a sea breeze.

LAND BREEZE In the evening, the sun goes down. The land and water cool off. But the land cools off faster than the water. The water is now warmer than the land.

The warmer and lighter air above the water rises. Cooler and heavier air that is over the land moves in to take its place.

This air that moves out from the land and heads towards the sea is a land breeze.

UNDERSTANDING LAND BREEZES AND SEA BREEZES

Look at Figures A and B. Then choose the correct term to complete each statement. Write your choice in the space.

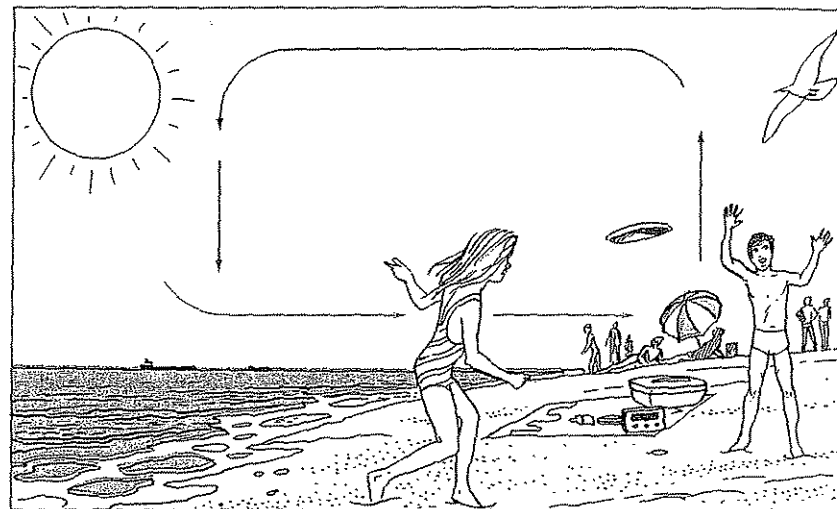


Figure A

1. In Figure A the _____ is warmer; the _____ is cooler.
land, water land, water
2. The air is warmer over the _____.
land, water
3. The air is cooler over the _____.
land, water
4. The air is lighter over the _____.
land, water
5. The air is heavier over the _____.
land, water
6. a) The air over the _____ rises.
land, water
b) Air that is over the _____ moves in to take its place.
land, water
7. This is an example of a _____ breeze.
land, sea
8. A sea breeze blows during the _____.
daytime, evening

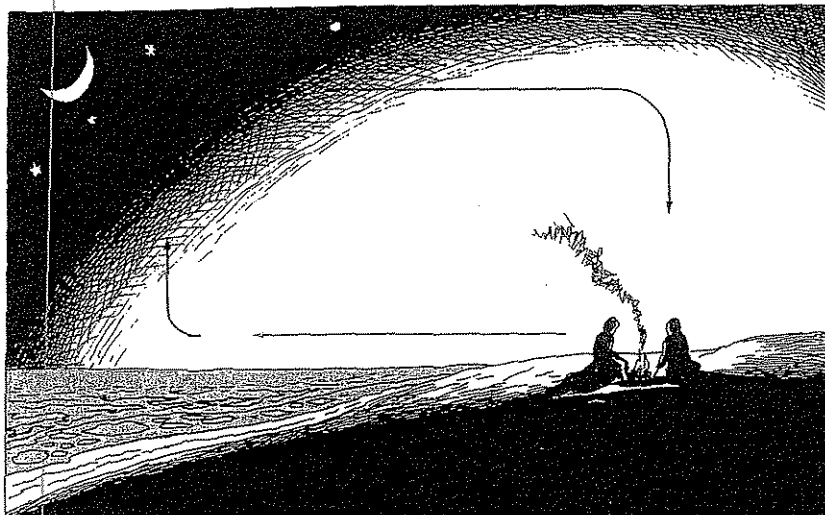


Figure B

1. In Figure B, the _____ is warmer; the _____ is cooler.
land, water land, water
2. The air is warmer over the _____.
land, water
3. The air is cooler over the _____.
land, water
4. The air is lighter over the _____.
land, water
5. The air is heavier over the _____.
land, water
6. a) The air over the _____ rises.
land, water
- b) Air that is over the _____ moves in to take its place.
land, water
7. This is an example of _____ breeze.
land, sea
8. A land breeze blows during the _____.
daytime, evening
9. A breeze is a _____ wind.
strong, mild

COMPLETING SENTENCES Complete the sentences with the choices below. Four of these may be used twice.

land
slower
sea breeze

breeze
sea
daytime

land breeze
faster
evening

1. Any gentle wind is called a _____.
2. The two kinds of shore breezes are the _____ and the _____.
3. A sea breeze blows during the _____.
4. A sea breeze blows from the _____ and moves towards the _____.
5. A land breeze blows during the _____.
6. A land breeze blows from the _____ and moves towards the _____.
7. Land heats up _____ than water.
8. Land cools off _____ than water.
9. Water heats up _____ than land.
10. Water cools off _____ than land.

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|----------------------|---|
| 1. _____ land breeze | a) heats up fast and cools fast |
| 2. _____ sea breeze | b) heats up slowly and cools slowly |
| 3. _____ water | c) starts from the land and moves toward the sea |
| 4. _____ land | d) rises |
| 5. _____ warm air | e) starts from the sea and moves towards the land |

FILL IN THE ANSWERS Look at Figures C and D. Then do the exercise that goes with each.

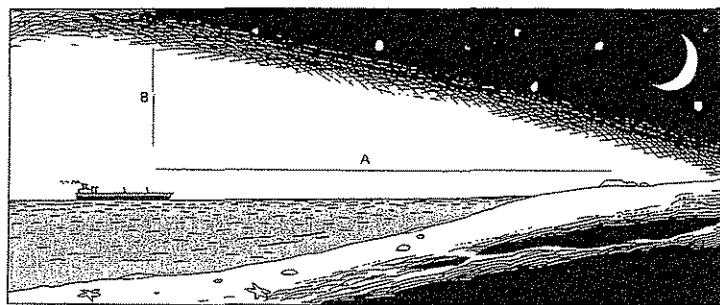


Figure C

Lines A and B stand for moving air.

1. Draw arrows on each line to show how it is moving.
2. The current is line _____
A, B
3. a) The shore breeze is line _____
A, B
- b) What kind of shore breeze is it? _____

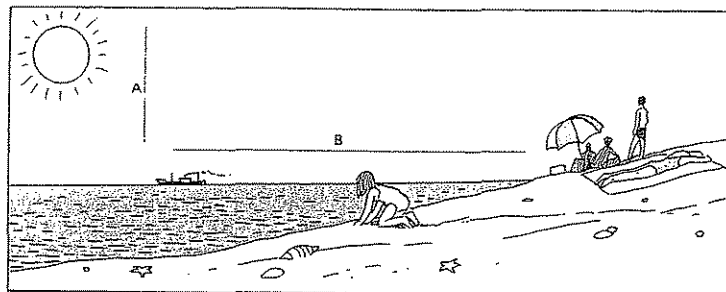


Figure D

Lines A and B stand for moving air.

4. Draw arrows on each line to show how it is moving.
5. The current is line _____
A, B
6. a) The shore breeze is line _____
A, B
- b) What kind of shore breeze is it? _____

ABOUT MONSOONS

A monsoon is like a very strong shore breeze. It covers a very large area. It is caused by the uneven heating and cooling of land and water areas. But a monsoon does not change from day to night. A monsoon changes from season to season.

The greatest monsoons happen in India and southeast Asia.

The maps below show the monsoon winds of India.

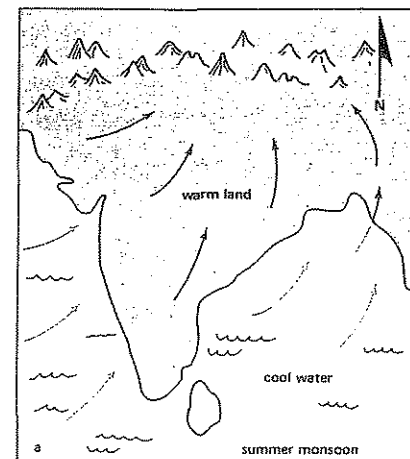


Figure E

During the summer, monsoon winds blow from the sea to the land.

This wind has a lot of moisture from the water. It causes heavy rain.

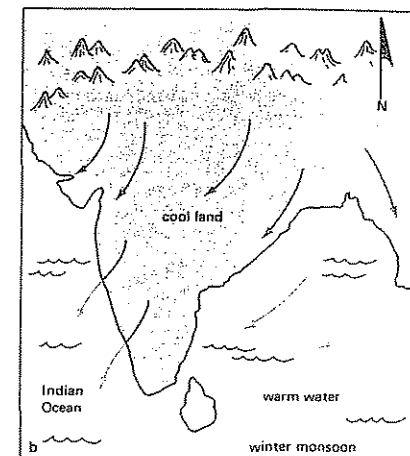


Figure F

During the winter, monsoon winds blow from the land to the water.

This wind is dry.

1. In the summer, monsoon winds blow _____ the land.
towards, away from
2. In the winter, monsoons blow _____ the land.
towards, away from
3. In the summer, monsoon winds are _____
wet, dry
4. In the winter, monsoon winds are _____
wet, dry
5. The monsoon winds change with _____
each day, the seasons

TRUE OR FALSE Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

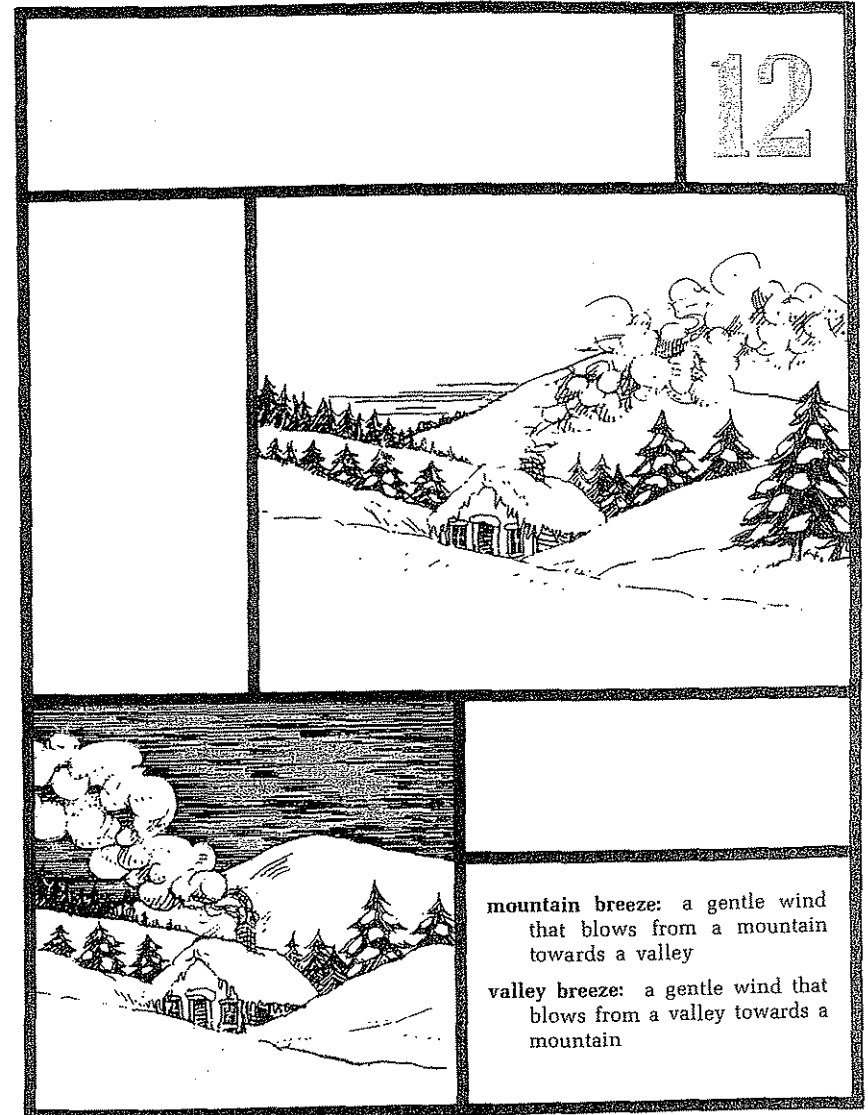
1. _____ Sea breezes and land breezes are planetary winds.
2. _____ A sea breeze is a daytime breeze.
3. _____ A land breeze is an evening breeze.
4. _____ A land breeze comes from the sea.
5. _____ Land heats up faster than water.
6. _____ Land cools off faster than water.
7. _____ A monsoon is like a huge shore breeze.
8. _____ A monsoon covers a small area.
9. _____ Uneven heating and cooling of water and land cause monsoons.
10. _____ Monsoons happen all over the world.

REACHING OUT

Sometimes it gets cool extra fast at night. Would this make a land breeze blow slower or faster? Why? _____

WHAT ARE VALLEY AND MOUNTAIN BREEZES?

12



AIM | What are valley and 12 mountain breezes?

Do you live near a mountain? People who live near mountains often feel special, gentle local winds. They are called valley breezes and mountain breezes.

Valley breezes and mountain breezes are caused by the uneven heating and cooling of mountains and valleys.

VALLEY BREEZE On a hot, sunny day, the air in a valley may become very warm. This warm air is light. It moves up the mountain slope that is above the valley.

The air that moves up from the valley is called a valley breeze.

MOUNTAIN BREEZE At night, air begins to cool down. The side of the mountain cools off very fast. So does the air close to it. The valley is sheltered so it keeps some of its heat. The cooler and heavier air from the mountain begins to flow down the slope. It moves into the valley below.

This air that moves down from the mountain is called a mountain breeze.

UNDERSTANDING MOUNTAIN AND VALLEY BREEZES

Look at Figures A and B. Then complete the sentences that go with each.

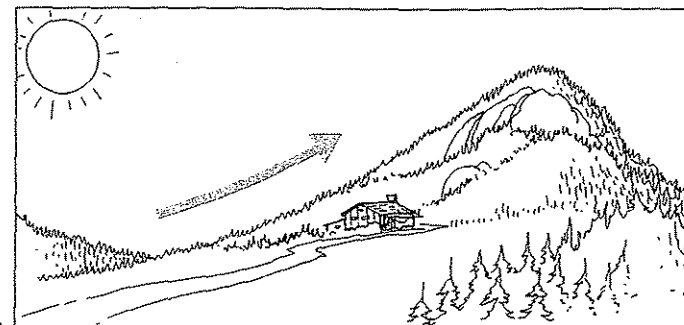


Figure A

1. When the sun is shining, air in the valley _____ heats up, cools down.
2. The air in the valley is _____ lighter, heavier _____ than the air by the mountain.
3. The air in the valley _____ rises, flows downward _____.
4. a) Air is moving from the _____ mountain, valley _____ to the _____ mountain, valley _____.
- b) What do we call this kind of breeze? _____
- c) This is _____ a daytime, an evening _____ breeze.

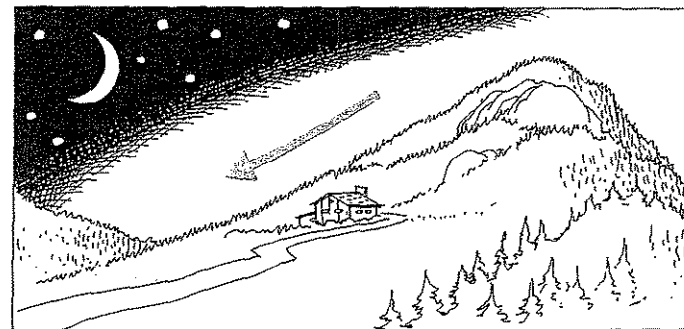


Figure B

5. When the sun goes down, the air _____ in the valley, by the mountain _____ cools more rapidly.
6. This cooler air is _____ heavier, lighter _____.

7. The air next to the mountain _____ rises, flows downward.
8. a) Air is moving from the _____ to the _____
mountain, valley mountain, valley
- b) What do we call this kind of breeze? _____
- c) This is _____ breeze.
a daytime, an evening

COMPLETING SENTENCES

Complete the sentences with the choices below.

- | | | |
|-------------------|------------------------|--|
| daytime
valley | local winds
evening | uneven heating and cooling
mountain |
|-------------------|------------------------|--|
- Valley and mountain breezes are special _____.
 - Valley and mountain breezes are caused by _____ of valleys and mountains.
 - A valley breeze blows during the _____.
 - A mountain breeze blows during the _____.
 - A valley breeze blows from a _____.
 - A mountain breeze blows from a _____.

MATCHING

Match the two lists. Write the correct letter on the line next to each number.

- | | |
|--------------------------------------|-------------------|
| 1. _____ valley breeze occurs | a) local winds |
| 2. _____ mountain breeze occurs | b) drops |
| 3. _____ valley and mountain breezes | c) at night |
| 4. _____ warm air | d) rises |
| 5. _____ cool air | e) during the day |

TRUE OR FALSE

Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

- _____ Valley breezes and mountain breezes are local winds.
- _____ Valley breezes and mountain breezes are caused by the uneven heating and cooling of the land and water.
- _____ A valley breeze blows during the daytime.
- _____ A valley breeze blows from a mountain.
- _____ A mountain breeze blows during the daytime.
- _____ A mountain breeze blows from a mountain.

NAME THE BREEZE

One of these figures shows a valley breeze. The other one shows a mountain breeze. Write Figure C or Figure D on the correct blanks.

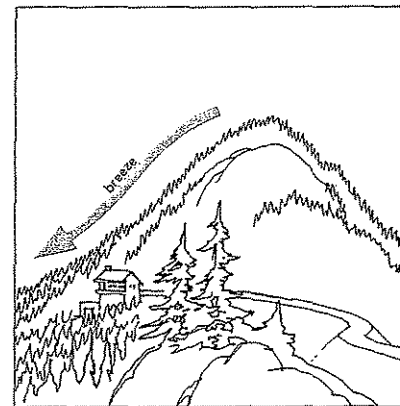


Figure C

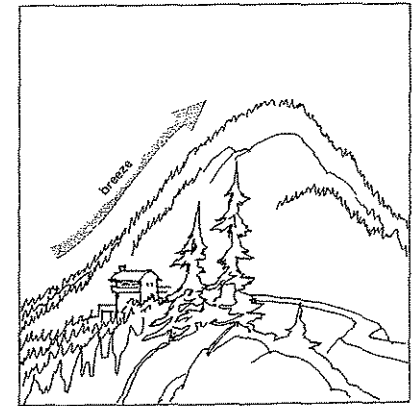


Figure D

- Which one is the valley breeze? _____
- Which one is the mountain breeze? _____
- Which one is happening at night? _____
- Which one is happening during the daytime? _____

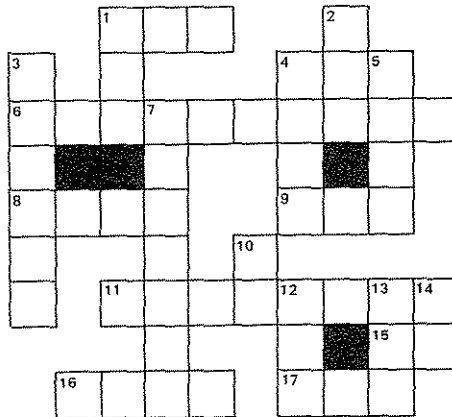
REACHING OUT

On nights when it is cloudy, the air close to the mountainside does not cool as rapidly. Would this make the mountain breeze flow faster or slower? Explain.

CROSSWORD Fill in the blank spaces by following the clues across and down.
PUZZLE

Across

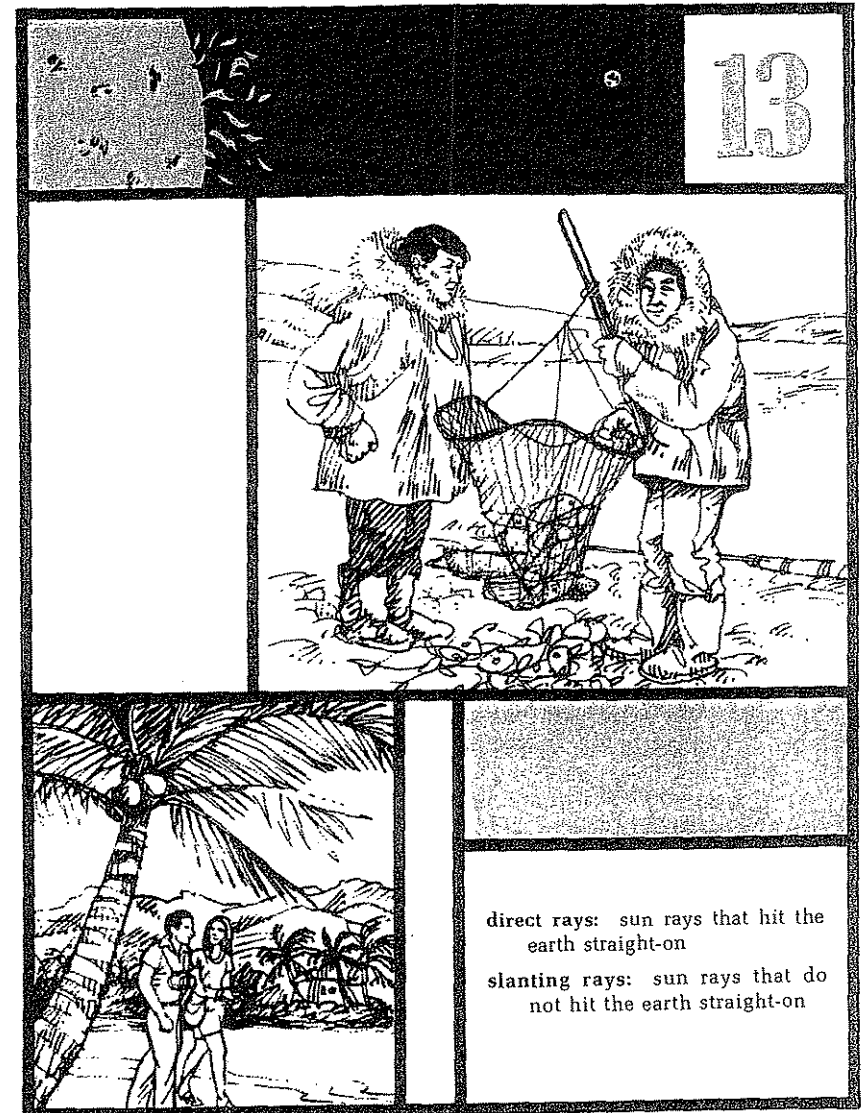
1. Large body of water
4. What you wear on your head
6. Measures wind speed
8. Tilt
9. Black and sticky substance
11. Land above a valley
15. Direction opposite SW
16. Shows wind direction
17. A writing tool



Down

- | | |
|--|---|
| 1. You do this with your eyes | 7. Seasonal wind |
| 2. Larger than a mouse (also 9 across/backwards) | 10. Not off |
| 3. Low land between mountains | 12. Hit lightly |
| 4. Warming energy from the sun | 13. Old time hotel |
| 5. Rip | 14. Direction between north and east (abbreviate) |

WHY ARE SOME PLACES HOT AND OTHERS COLD?



direct rays: sun rays that hit the earth straight-on

slanting rays: sun rays that do not hit the earth straight-on

AIM | Why are some places hot 13 and others cold?

What would you wear at the equator? As little as possible! You know that it is usually hot at the equator.

Would you dress the same way at the North or South Pole? Not if you wanted to stay alive!

At the poles it is always very cold. You must wear thick, warm clothing. Why is it sizzling at the equator and freezing at the poles? It is because the equator and the poles receive the sun's light at different angles.

You can see how the rays strike the earth by using the model in Figure A. The globe stands for the spinning earth. Notice that it is slightly tilted. So is the earth. The beams from the flashlights stand for the sun's rays.

The beam that strikes near the equator of the globe hits *straight-on*. But the beam that strikes near the North Pole hits at an angle and so covers a much larger area. The same amount of light energy *s p r e a d s o u t*.

The same is true of the earth. The rays that strike near the equator are straight on. These are called *direct rays*. Direct rays heat up the land and water greatly.

Rays that spread out over larger areas are called *slanting rays*. The sun's rays are most slanting at the poles. Slanting rays do not heat up the land and water as much as direct rays.

DIRECT AND INDIRECT RAYS

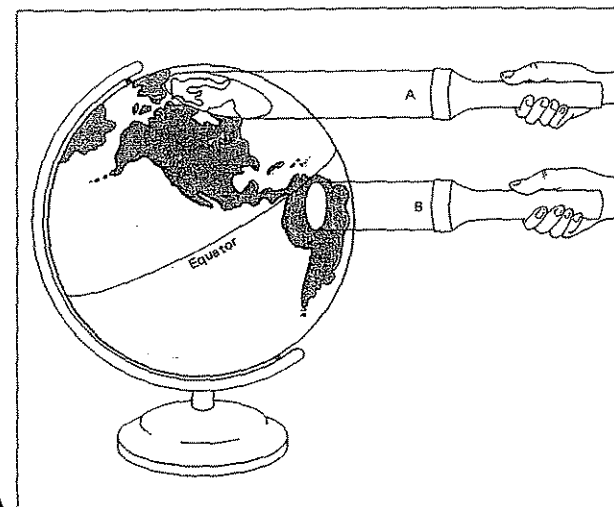


Figure A

Look at Figure A carefully. Then fill in the blanks.

Rays A and B are the same size before they hit the earth.

- Which of these rays hits the earth straight-on? _____
A. B
- Straight-on rays are called _____ rays.
- Direct rays _____ spread out.
do. do not
- Places that receive direct rays are _____.
hot. cold
- Which part of the earth receives direct rays? _____
- Which of these rays hits the earth at an angle? _____
A. B
- Slanting rays _____ spread out.
do. do not
- Slanting rays mean _____ heat.
more. less
- Where are the sun's rays most slanting? _____
- Take a guess! The sun's rays become slanting because the earth is _____
far from the sun. curved

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|--------------------------|-----------------------|
| 1. _____ direct rays | a) curved |
| 2. _____ slanting rays | b) do not spread out |
| 3. _____ equator | c) get the least heat |
| 4. _____ poles | d) spread out |
| 5. _____ earth's surface | e) gets the most heat |

EFFECT OF SLANTING?

Look at Figure B. Then answer each question with the correct letter.

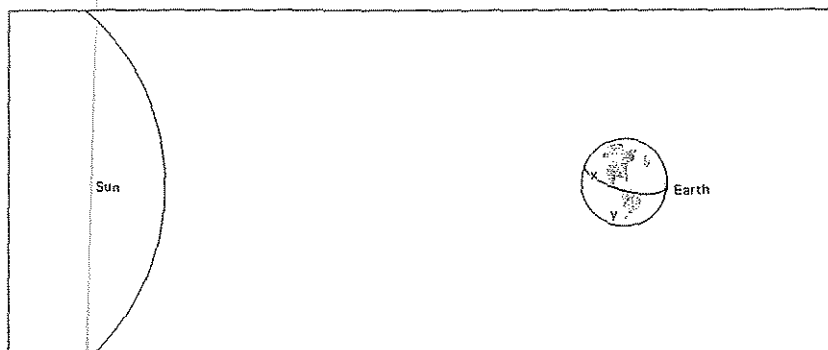


Figure B

- Where are there more direct rays? _____
- Where are there more slanting rays? _____
- Which place is cooler? _____
- Which place is warmer? _____

WHAT IS WEATHER?

14

humidity: water vapor in the air

precipitation: rain, snow, hail, sleet, or drizzle

AIM | What is weather?

14

We probably talk about weather more often than anything else. How often have you started talking to people by saying, "Wow, look at that rain!" or "This heat is too much!"?

Weather affects us in many ways. We dress according to the weather. We make plans hoping for fair weather. Sunny weather can make you feel happy. Rainy weather can make you feel sad.

Weather affects what kind of food you eat. It even affects how much your family pays for food.

Weather is very, very important to everyone. But, what is weather?

Weather is the condition of the lower atmosphere. It is different from place to place. Weather is always changing from moment to moment.

Several things make up weather. They are:

- air temperature
- air pressure
- precipitation [pree sip uh TAY shun] (rain, snow, hail, sleet, drizzle)
- appearance of the sky (clear or cloudy)
- wind speed
- wind direction
- humidity (water in the air)

You will learn about weather in the next Aims. You will also learn to read a weather map. In fact, you will learn to make your own weather map. It's easy—and it's fun.

HOW WEATHER AFFECTS US

Weather affects the lives and jobs of many people. It affects how we get from place to place.



Figure A



Figure B

It affects how we live.



Figure C

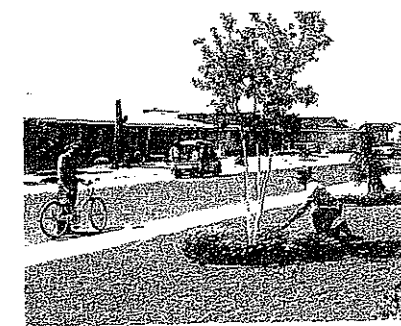


Figure D

Weather affects how we work.



Figure E



Figure F

Weather even affects how we play.



Figure G



Figure H

1. Can you think of other ways in which we are affected by the weather? _____

2. Name a kind of job that is affected by the weather. _____

WHAT DO THE PICTURES SHOW?

Look at each picture. Each of the pictures below hints at some part of weather.

On the line under each picture, write the part of weather you think it shows. Choose from the list.

humidity
air pressure

appearance of sky
wind speed and direction

precipitation
temperature



Figure I

1. _____



Figure J

2. _____



Figure K

3. _____

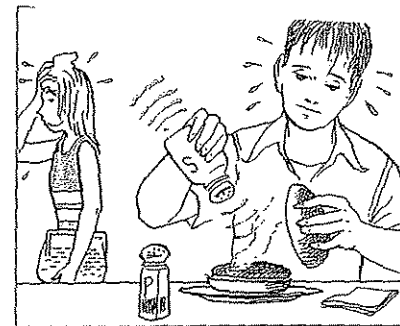


Figure L

4. _____

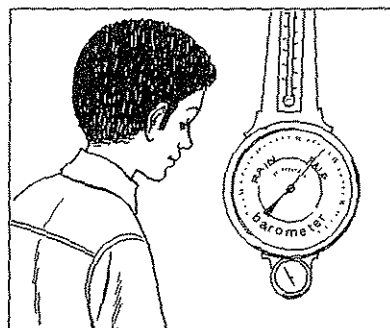


Figure M

5. _____



Figure N

6. _____

TRUE OR FALSE

Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

- _____ Air pressure is part of the weather.
- _____ Most weather takes place in the troposphere. (Look back to Aim 2 if you have to.)
- _____ Weather is the same everywhere.
- _____ Weather can change quickly.
- _____ Water is always a liquid.

COMPLETING SENTENCES

Complete the sentences with the choices below.

hot	how something looks	water
moisture	weighs	wind direction
clouds	wind speed	gas
precipitation	cold	

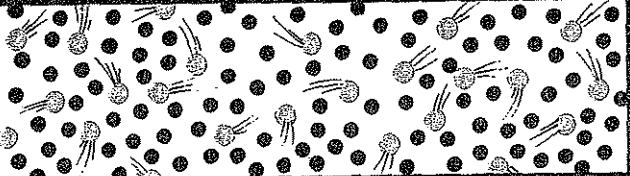
- Air pressure has to do with how much the air _____.
- Temperature tells us how _____ or _____ the air is.
- Rain, snow, hail, sleet, and drizzle are examples of _____.
- Precipitation is made up of liquid or frozen _____.
- "Appearance" means _____.
- The appearance of the sky is changed by _____.
- "20 kilometers per hour" can describe _____.
- "Northwest" can describe _____.
- Humidity is the same as _____.
- Humidity is water in the _____ form.

REACHING OUT

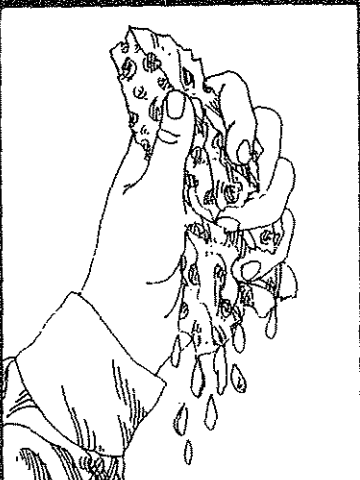
- How can the weather affect the price of food?

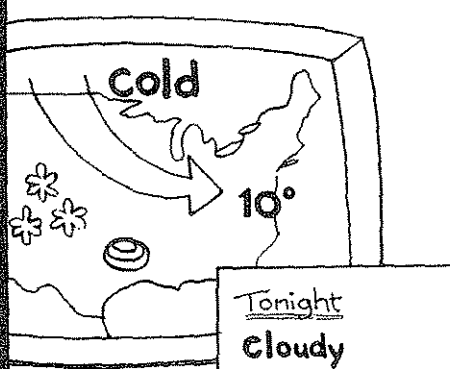
- Only one of the things that make up weather can be experienced on the moon. What is it? _____
 - Why doesn't the moon have the other things that make up weather? _____

WHAT IS RELATIVE HUMIDITY?



15





Tonight
Cloudy

Temperature
10°

Humidity
56%

relative humidity: the amount of water vapor in the air compared to how much the air can hold

saturated: filled up

AIM | What is relative humidity? 15

Try this: Fill a large pan with water. Then place a sponge into the pan.

What happens? The sponge soaks up the water—but not all of it. The sponge soaks up water until it is “full.” Then it cannot soak up any more. We say the sponge is saturated [SACH uh ray tid].

The air is like a sponge. Air can also hold water. Water in the air is in the form of gas. Water in gas form is called water vapor.

The amount of water vapor in the air does not stay the same. Sometimes the air has only a small amount of water vapor. Sometimes it has a lot.

The air can only hold so much water. When there is more than that, there is precipitation.

The amount of water vapor air can hold depends on the temperature. Warm air can hold more water vapor than cold air. The higher the temperature, the more water vapor the air can hold.

Relative humidity tells us how “full” air is with water vapor.

Relative humidity compares

the amount of water vapor in the air with
the amount the air can hold.

Relative humidity is written as a percent (%). For example:

(a) The relative humidity of saturated air is one hundred percent (100%). Saturated air has all the water vapor it can hold.

(b) The relative humidity is 50% when the air holds only half the water vapor that it can.

Relative humidity can be very low. It can reach near zero percent. But it can never be at zero percent. Even the driest air has some water vapor.

STUDYING RELATIVE HUMIDITY

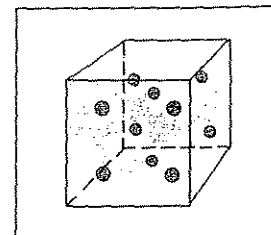


Figure A

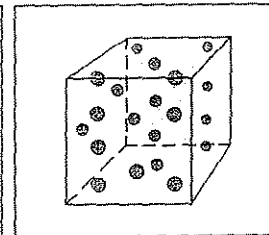


Figure B

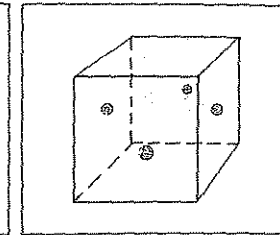


Figure C

Each cube stands for a part of the air. The temperature of each is 24°C (75°F). The balls stand for water vapor. You know that there are other gases in the air. Only water vapor is shown.

Write the letter of the correct cube in the blank.

- a) Which air has the least water vapor? _____
 b) Which air has the most water vapor? _____
- a) Which air is the driest? _____
 b) Which air is the dampest? _____
- a) Which air has the highest relative humidity? _____
 b) Which air has the lowest relative humidity? _____
- What do you think? Which air may have rain soon? _____

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|--------------------|------------------------------|
| 1. _____ vapor | a) can hold less water vapor |
| 2. _____ percent | b) gas |
| 3. _____ saturated | c) filled up |
| 4. _____ cold air | d) can hold more water vapor |
| 5. _____ warm air | e) part of one hundred |

COMPLETING SENTENCES

Complete the sentences with the choices below.

saturated	water vapor	damp	little
less	0%	relative humidity	
100%	more	lot	

- Water in gas form is called _____.
- Dry air has a _____ water vapor.
- Moist air has a _____ of water vapor.
- Cold air can hold _____ water vapor than warm air.
- The higher the temperature, the _____ water vapor air can hold.
- Air that holds all the water vapor it can is called _____ air.
- Saturated air feels very _____.
- The amount of water vapor in the air compared to the amount it can hold is called _____.
- The highest relative humidity is _____.
- The lowest relative humidity is nearly _____.

UNDERSTANDING PERCENTAGES

One hundred percent (100%) is a full amount of anything. For example:

- 100 parts of 100 is 100%
- 50 parts of 50 is 100%
- 2 parts of 2 is also 100%

Fifty percent (50%) is one-half of anything. For example:

- 50 parts of 100 is 50%
- 25 parts of 50 is 50%
- 1 part of 2 is 50%

- 100% of 20 is _____
100, 20, 120
- 50% of 20 is _____
20, 70, 10
- 25% of 20 is _____
5, 25, 45
- 10% of 20 is _____
2, 20, 10

FINDING RELATIVE HUMIDITY

Each cube in Figures D-H stands for a part of the air. The temperatures are the same. Each ball stands for one part of water vapor.

Twenty parts of water vapor makes each cube saturated. Twenty parts of water vapor is all that the air can hold at this temperature. With twenty parts of water vapor, the air has 100% relative humidity.

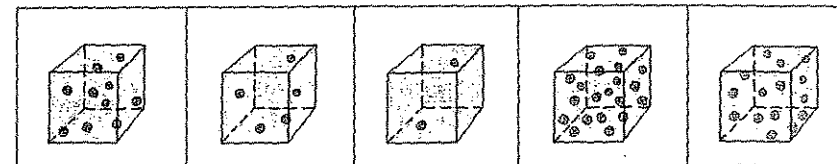


Figure D Figure E Figure F Figure G Figure H

Study each diagram. Then answer these questions. (Use Figure letters.)

- Which cube of air is saturated? _____
 - What is the relative humidity of the air in this cube? _____
 - Can this air hold any more water vapor? _____
- Which air has
 - 50% relative humidity? _____
 - 75% relative humidity? _____
 - 25% relative humidity? _____
 - 10% relative humidity? _____
- Which air is the driest? _____
- Which air is the dampest? _____
- Which air can hold these many *more* parts of water vapor?
 - 18 _____
 - 5 _____
 - 10 _____
 - 15 _____

DO YOU REMEMBER?

Air has many other gases. When more and more water vapor is added, it makes the other gases spread out more.

This makes the air pressure _____ higher, lower. If you don't remember, look back to Aim 5.

REACHING OUT

What happens if the air is saturated and the temperature drops? _____

WORD SEARCH The words in this list are hidden within the groups of letters. Try to find each word. When you find it, circle the word. The spelling may go backwards or forwards in any direction: up-and-down, across, or diagonally.

PRECIPITATION

POLE

DIRECT

RAYS

EQUATOR

HUMIDITY

WEATHER

TEMPERATURE

SKY

RELATIVE

HOT

SATURATE

VAPOR

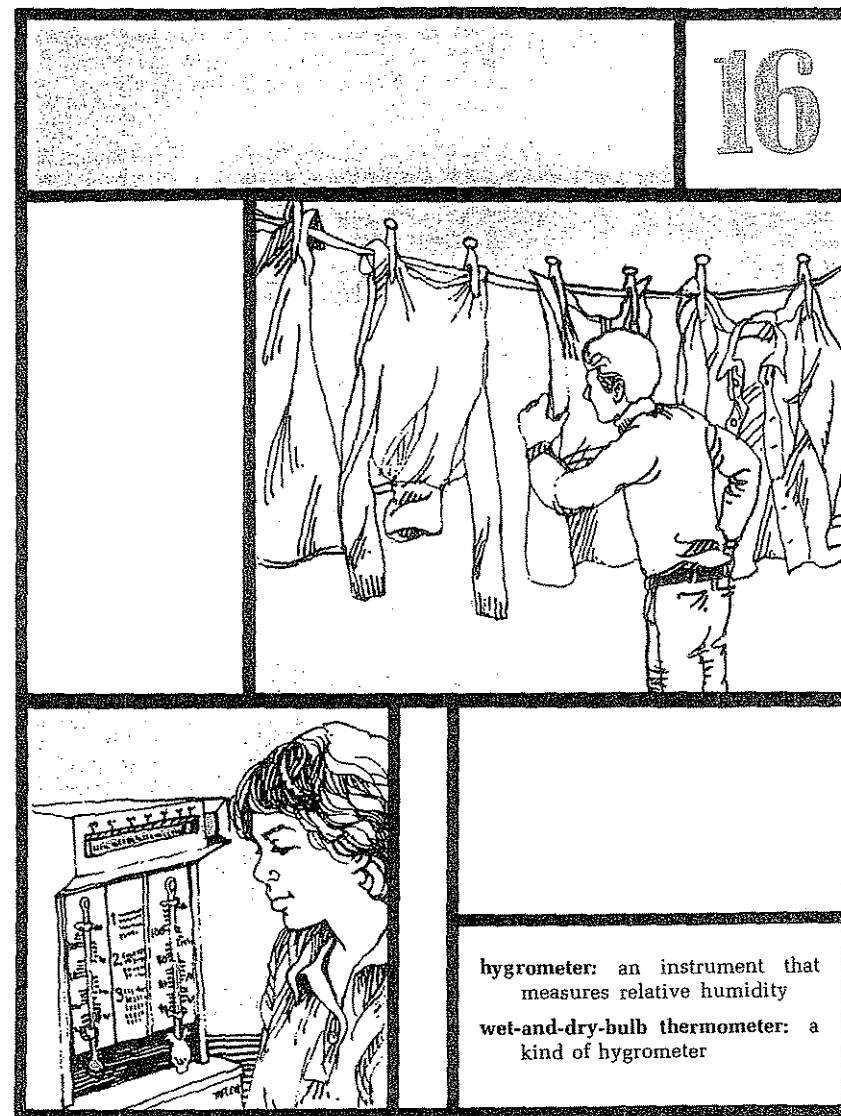
HEAT

COLD

A	B	T	D	S	S	N	Q	T	E	M	H	A	S
P	R	C	U	Y	E	A	F	L	Q	S	U	L	P
A	D	E	A	T	R	W	O	S	U	A	M	C	G
P	P	R	E	C	I	P	I	T	A	T	I	O	N
E	V	I	T	A	L	E	R	I	T	U	D	L	V
T	I	D	I	R	O	P	A	V	O	R	I	D	S
A	H	H	W	E	A	T	H	E	R	A	T	K	U
E	Q	H	O	Z	A	R	D	D	I	T	Y	P	R
H	E	R	U	T	A	R	E	P	M	E	T	C	C

HOW DO WE MEASURE RELATIVE HUMIDITY?

16



hygrometer: an instrument that measures relative humidity

wet-and-dry-bulb thermometer: a kind of hygrometer

AIM | How do we measure relative humidity?

16

Have you ever tried air-drying clothes on a humid day? It takes a long time. The air already contains many water molecules. The water from the clothes evaporates very slowly. Evaporate means to turn into a gas.

How fast evaporation takes place depends on the humidity. When the water does evaporate something happens. The surface that had been wet becomes cooler. For example, when the sweat on your body evaporates, your skin cools down.

Now you know two important facts about evaporation.

(1) Water evaporates slowly when the air is damp. It evaporates faster when the air is dry.

(2) When water evaporates, the temperature goes down.

These facts make it possible to measure relative humidity. Relative humidity is measured with a hygrometer [hie GROM uh tur]. One type of hygrometer is the wet-and-dry-bulb thermometer.

A wet-and-dry-bulb thermometer has two thermometers. One of the thermometers has a wet cloth around the bulb. This is the wet bulb. The thermometer without the wet cloth is the dry bulb.

■ The dry-bulb thermometer measures the normal air temperature.

■ The temperature of the wet-bulb thermometer depends on how fast the water evaporates.

When the air is saturated, no evaporation takes place. The temperature of the wet-bulb thermometer is the same as the dry-bulb thermometer.

But when the air is not saturated, evaporation does take place. The wet bulb cools down. It has a lower temperature than the dry bulb.

If the wet bulb has a much lower temperature than the dry bulb, it means the air is not very humid.

FIND THE PARTS Figure A shows a wet-and-dry-bulb thermometer. Find the parts listed below. Then write the letter of each part on the correct line.

- _____ wet-bulb thermometer
_____ dry-bulb thermometer
_____ water
_____ wet cloth

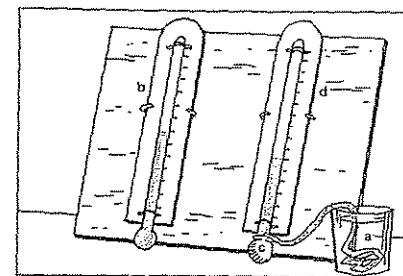


Figure A

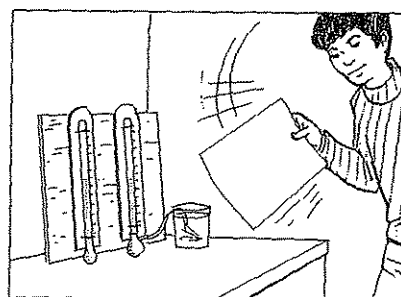


Figure B

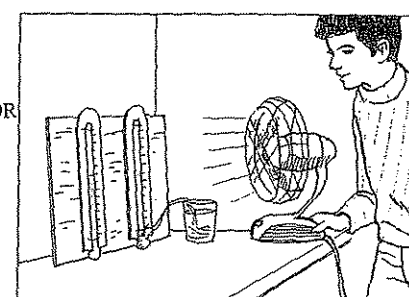


Figure C

You should fan a wet-and-dry-bulb thermometer before you read the temperatures. This keeps air moving around the wet bulb so that the water evaporates.

You can even spin the thermometers. The hygrometer in Figure D is also called a sling psychrometer [sy KROM uh tur].

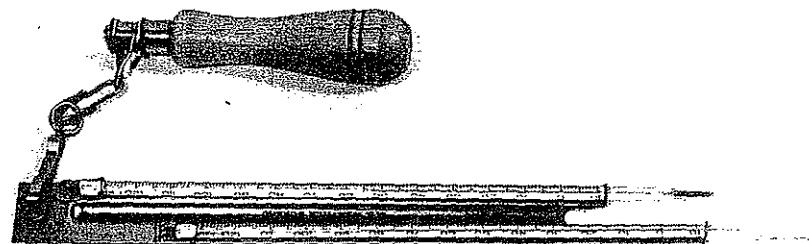


Figure D

HOW TO USE THE WET AND DRY THERMOMETER CHART

In order to find out the relative humidity after you read the temperatures, you must use a chart (Figure E).

1. Find the dry-bulb temperature readings on the chart (column a).
2. Find the temperature difference between the wet and dry thermometers on the chart. (Look on line b.)
3. Follow both numbers into the chart. Where the two numbers meet is the percentage relative humidity.

The chart shows one example.

■ IF the dry thermometer reads 80°F and the wet-bulb thermometer reads 75°

■ THEN, the temperature difference between the dry and wet thermometers is 5°.

■ THEREFORE, the relative humidity is 79%.

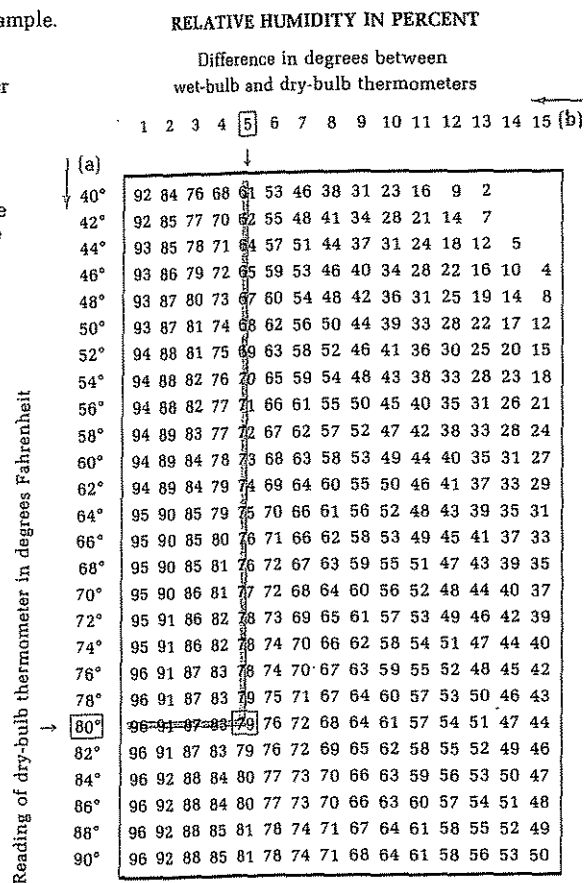


Figure E

FINDING RELATIVE HUMIDITY

Fill in the missing numbers in the boxes below.
Use the chart on the facing page.

	Dry-bulb Temperature °F	Wet-bulb Temperature °F	Temperature Difference	Percentage Relative Humidity
1.	78	73		
2.	54	39		
3.	74	66		
4.	40	29		
5.	90	89		
6.	76	71		
7.	90	75		
8.	62	52		
9.	82	71		
10.	48	37		
11.	80	77		
12.	46	35		

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|----------------------------|---|
| 1. _____ water vapor | a) the amount of water vapor that air can hold at a given temperature |
| 2. _____ relative humidity | b) can hold little water vapor |
| 3. _____ warm air | c) measures relative humidity |
| 4. _____ cold air | d) can hold a lot of water vapor |
| 5. _____ hygrometer | e) water in gas form |

COMPLETING SENTENCES

Complete the sentences with the choices below.

100%
evaporates
cooler
hygrometer

percent
wet-and-dry-bulb thermometer
fan
air temperature

spin
two
dry

1. Any instrument that measures relative humidity is called a _____.
2. The _____ is one kind of hygrometer.
3. A wet-and-dry-bulb thermometer has _____ thermometers.
4. The dry bulb measures _____.
5. The wet bulb temperature depends on how fast the water _____.
6. Before we read the temperatures of the wet-and-dry-bulb thermometer, we should first _____ or _____ it.
7. Evaporation makes things drier and _____.
8. Evaporation happens faster when the air is _____.
9. Relative humidity is written as a _____.
10. Water does not evaporate when the relative humidity is _____.

REACHING OUT

You can make your own wet-and-dry-bulb thermometer. Figure F shows what it should look like.

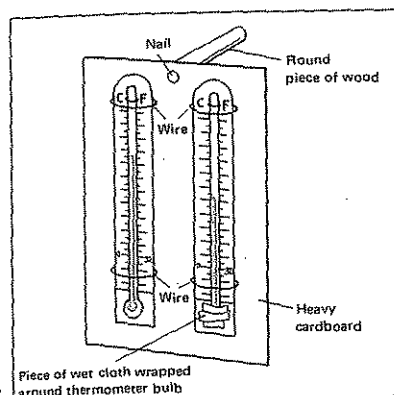
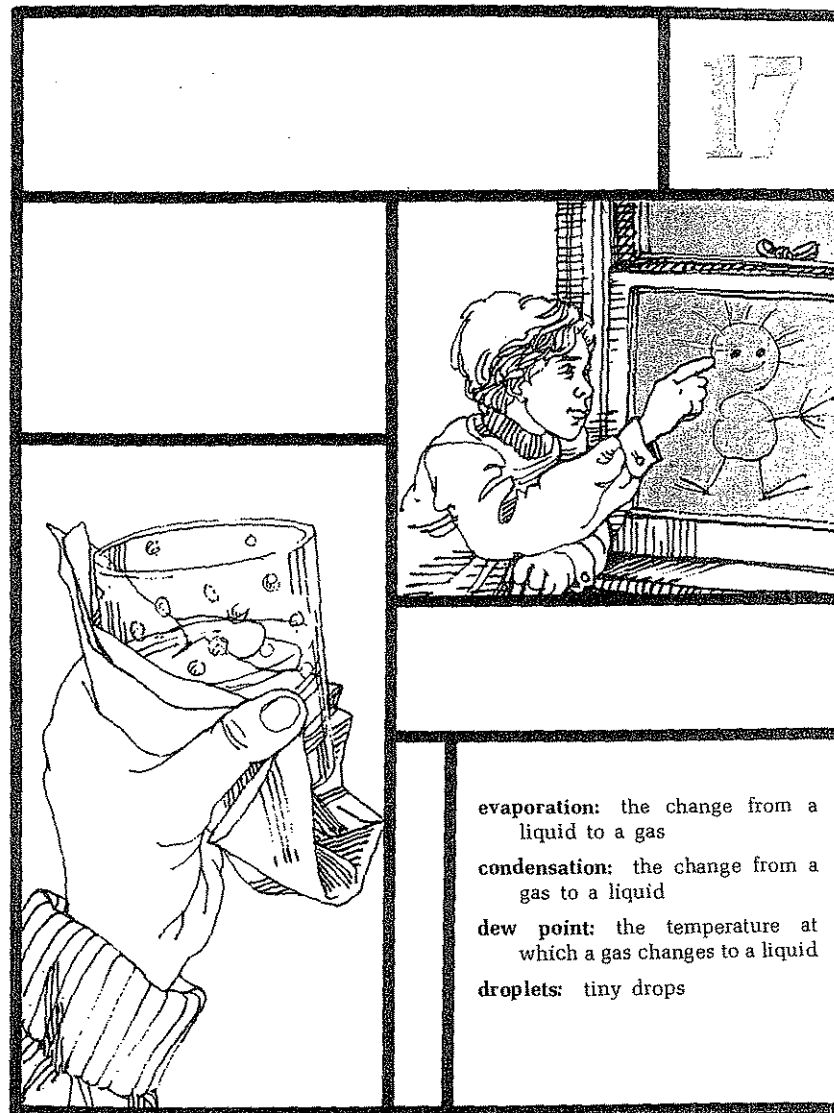


Figure F

HOW DO CLOUDS FORM?

17



evaporation: the change from a liquid to a gas

condensation: the change from a gas to a liquid

dew point: the temperature at which a gas changes to a liquid

droplets: tiny drops

AIM | How do clouds form?

17

You cannot see water vapor. But you can change water vapor into liquid water which you can see.

This is how to do it: Pour some water into a pitcher. Add ice. Let it stand. Soon the pitcher is covered with a thin layer of water (Figure B).

The water on the outside of the pitcher comes from the air. The cold pitcher cools the air around the pitcher. Now the air can hold less water vapor. In fact, it has more water vapor than it can hold.

The extra water vapor comes out of the air. It changes to liquid water and settles on the pitcher.

The change from a gas to a liquid is called condensation [kon den SAY shun].

The temperature at which condensation takes place is called the dew point.

NOW LET'S USE THESE FACTS TO LEARN HOW CLOUDS ARE FORMED.

A cloud starts out as moist air. Moist air is lighter than dry air. It rises into the sky.

As the air rises, it cools. When it cools enough, it reaches its dew point. Some of the water vapor in the air condenses. It changes to tiny droplets of water.

Droplets are very light. They are so light that other rising air keeps them from falling to earth.

As more humid air rises, more water vapor condenses. Little by little, billions and billions of droplets build up.

These countless numbers of droplets form what we call a cloud.

UNDERSTANDING CONDENSATION

Study Figures A and B. Then choose the correct term for each statement. Write your choice in the space.



Figure A



Figure B

Look at Figure B to answer the questions.

1. The pitcher in Figure B is _____ than the air.
warmer, cooler
2. The pitcher in Figure B _____ the air close to it.
cools, warms
3. The air next to the pitcher now can hold _____ water vapor.
more, less
4. Some water vapor in the air touching the pitcher _____.
evaporates, condenses
5. Condensation changes _____.
a liquid to a gas, a gas to a liquid
6. What do we call the temperature at which condensation takes place?

TRACING THE MAKING OF A CLOUD

Match the letters in the diagram with the descriptions. Write the proper letters on the blank lines. Some of these letters may be used more than once.

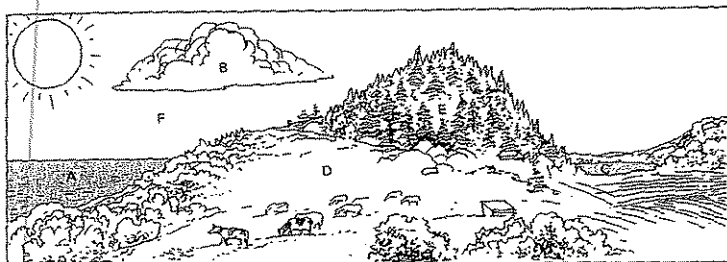


Figure C

1. Water evaporates from _____, _____, _____, and _____.
2. The air is cooling at _____.
3. Condensation has happened at _____.
4. Water is changing to a gas at _____, _____, _____, _____, and _____.
5. Water vapor is changing to liquid water at _____.

MATCHING

Match the two lists. Write the correct letter on the line next to each number.

- | | |
|----------------------------|---|
| 1. _____ evaporation | a) the temperature at which a gas changes to a liquid |
| 2. _____ condensation | b) the colder it gets |
| 3. _____ dew point | c) the change from a liquid to a gas |
| 4. _____ the higher you go | d) made up of billions of water droplets |
| 5. _____ cloud | e) the change from a gas to a liquid |

COMPLETING SENTENCES

Complete the sentences with the correct word.

saturated
evaporation
dew point
droplet

cloud
condensation
water vapor

more
liquid water
invisible

1. Water in the gas form is called _____.
2. The change from liquid water to water vapor is called _____.
3. Water vapor is _____.
4. Warm air can hold _____ water vapor than cool air can.
5. Air that holds all the water vapor that it can is said to be _____.
6. When saturated air cools, extra water vapor changes to _____.
7. The change from water vapor to liquid water is called _____.
8. The temperature at which condensation takes place is called the _____.
9. A very tiny drop is called a _____.
10. Many, many billions of droplets make up a _____.

TRUE OR FALSE

Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

1. _____ You can always see water.
2. _____ Water vapor is invisible.
3. _____ A vapor is a gas.
4. _____ Evaporation is the change from a gas to a liquid.
5. _____ Saturated air cannot hold any more water vapor.
6. _____ Cold air can hold less water vapor than warm air.
7. _____ Evaporation happens at the dew point.
8. _____ When warm air rises, it cools off.
9. _____ Condensation happens when air cools.
10. _____ A cloud is made up of water vapor.

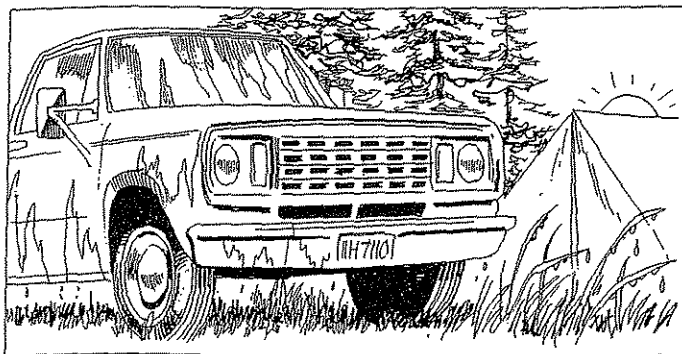


Figure D

Everyone has seen dew. We see it on the morning grass. We have seen it cover automobiles.

The sentences below tell how dew is formed. But the sentences are not in the proper order.

Re-write these sentences in proper order on the blank lines below.

1. After the sun goes down, the air and earth cool off.
2. Some water vapor condenses. It changes to drops of dew.
3. During the daytime, the sun evaporates water.
4. The air reaches its dew point.
5. The air becomes moist.

WHAT ARE THE NAMES OF SOME CLOUDS?



18







cumulus:

stratus:

cirrus:

thunderhead:

}

kinds of clouds

fog: a cloud that touches the ground

AIM | What are the names of some 18 | clouds?

Can you walk through a cloud? Yes you can! Just take a walk when it is foggy.

A fog is one kind of cloud.

A fog is a cloud that is touching the ground.

Most clouds do not touch the ground. We have to look up into the sky to see them.

Clouds come in many shapes and sizes. Three kinds of clouds you often see are cumulus [KYOO myuh lus], stratus [STRAT us], and cirrus [SIR us].

CUMULUS CLOUDS are white and fluffy. They look like large puffs of cotton, (Figure A).

Cumulus clouds form mostly on warm summer days. Usually, they mean that the weather will be fair.

In hot weather, a cumulus cloud may grow extra big and turn dark. It becomes a thunderhead (Figure B).

A thunderhead is a storm cloud. It brings heavy rain with thunder and lightning.

STRATUS CLOUDS are low in the sky. They spread over a large area like a giant gray blanket (Figure C).

Stratus clouds are rain clouds.

CIRRUS CLOUDS are streaky. They look like thin feathers (Figure D).

Cirrus clouds are very high in the sky where it is very cold. They are made up of tiny ice crystals.

Cirrus clouds tell us that it may rain or snow within a day or two.

WHAT DO THE CLOUDS SHOW?

Study the pictures of the clouds below. Then answer the questions under the pictures.



Figure A

CUMULUS CLOUDS

1. What kind of weather do cumulus clouds bring? _____

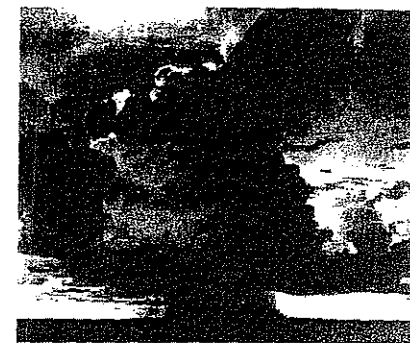


Figure B

A THUNDERHEAD

2. What kind of weather does a thunderhead bring? _____

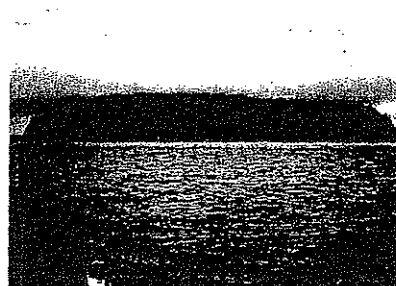


Figure C

STRATUS CLOUDS

3. What kind of weather do stratus clouds bring? _____



Figure D

CIRRUS CLOUDS

4. What do cirrus clouds tell us will happen? _____

COMPLETING SENTENCES

Complete the sentences with the choices below. Two of these may be used twice. One may be used three times.

ice
cumulus
sizes and shapes

droplets of water
stratus
condensed water vapor

cirrus
fog

1. A cloud is made up of billions of tiny _____.
2. The water that makes up clouds comes from _____.
3. A cloud that is touching the ground is called a _____.
4. Clouds come in many _____.
5. Three common kinds of clouds are _____, _____, and _____ clouds.
6. Gray clouds that spread over a large area are called _____.
7. Feathery-looking clouds are called _____ clouds.
8. Clouds that look like puffs of cotton are called _____ clouds.
9. A thunderhead builds up from a _____ cloud.
10. Cirrus clouds are made up of crystals of _____.

MATCHING

Match the two lists. Write the correct letter on the line next to each number.

- | | |
|----------------------|----------------------------------|
| 1. _____ cumulus | a) low, gray rain clouds |
| 2. _____ stratus | b) cloud that touches the ground |
| 3. _____ cirrus | c) storm cloud |
| 4. _____ thunderhead | d) fair-weather clouds |
| 5. _____ fog | e) ice clouds |

WHICH ONE?

Look at these pictures of clouds. Answer with the proper letter.

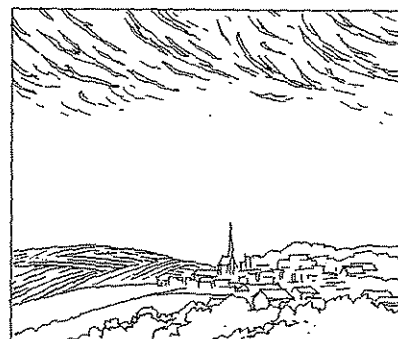


Figure E

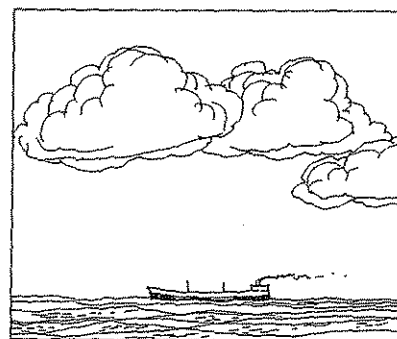


Figure F

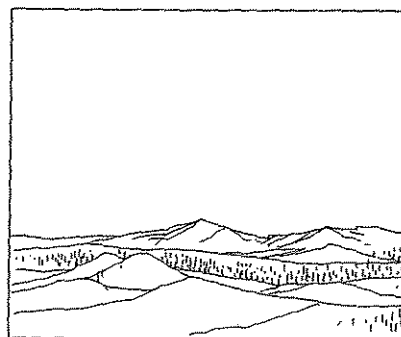


Figure G

Which picture . . .

1. shows stratus clouds? _____
2. shows cirrus clouds? _____
3. shows cumulus clouds? _____

Which kind of cloud . . .

4. is highest in the sky? _____
5. is lowest in the sky? _____
6. is made up of ice crystals? _____
7. means fair weather? _____
8. means possible rain or snow? _____
9. means rain? _____
10. may become a thunderhead? _____

TRUE OR FALSE Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

1. _____ Clouds are made up of water vapor.
2. _____ There is only one kind of cloud.
3. _____ A fog is a cloud.
4. _____ Stratus clouds are low clouds.
5. _____ Cumulus clouds mean fair weather.
6. _____ Stratus clouds are made of ice crystals.
7. _____ Cirrus clouds are the highest clouds.
8. _____ A thunderhead builds up from cirrus clouds.
9. _____ Stratus clouds are rain clouds.
10. _____ The sizes and shapes of clouds are always changing.

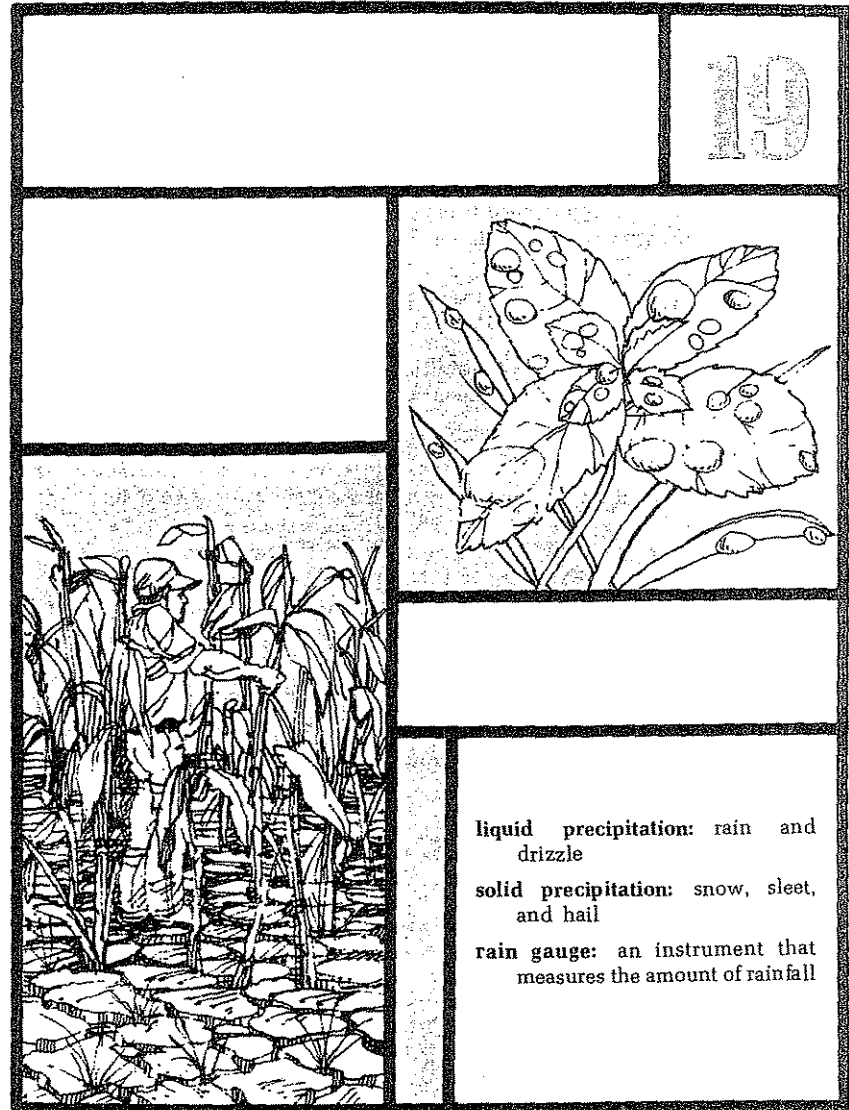
REACHING OUT

We often hear on the weather report that "the fog will burn away."

What does that mean? _____

WHY DOES WATER FALL FROM CLOUDS?

19



liquid precipitation: rain and drizzle

solid precipitation: snow, sleet, and hail

rain gauge: an instrument that measures the amount of rainfall

AIM | Why does water fall from clouds? 19 | clouds?

Can you imagine our planet without rain? All the water would evaporate. All the oceans, rivers, lakes, and streams would dry up. There would be no water for plants or animals. Nothing could live.

Luckily, this doesn't happen. Water does evaporate. But, it always comes back to earth!

Water comes back to the earth from clouds. But why do clouds give up this water? Why does water fall back to earth? Here is an explanation.

A cloud is made up of billions of tiny droplets of water. Droplets are very light. Rising air keeps them bouncing around.

As they bounce around, the droplets collide. They join up and become larger droplets.

This happens over and over again. The droplets become larger and larger. Finally, they become the size of drops. Drops are much larger and heavier than droplets. Rising air no longer can hold them up. So they fall to earth.

Water that falls to earth from clouds is called precipitation. There are five kinds of precipitation: rain, drizzle, snow, hail, and sleet.

Rain and drizzle are liquid precipitation. They form when the temperature is above freezing. That is 0°C or 32°F at sea level. Rain is made of drops. Drizzle is a fine spray made of droplets.

Snow, hail, and sleet are solid precipitation. They form when the temperature is freezing or below.

THE STORY OF "DROPS"

The Figures A, B, and C show how clouds give up drops. Complete the word story below and on the next page by filling in the blank spaces. Choose from the following terms.

over and over again
cannot
fall
light in weight

water
collide
drops

precipitation
heavier
rising air

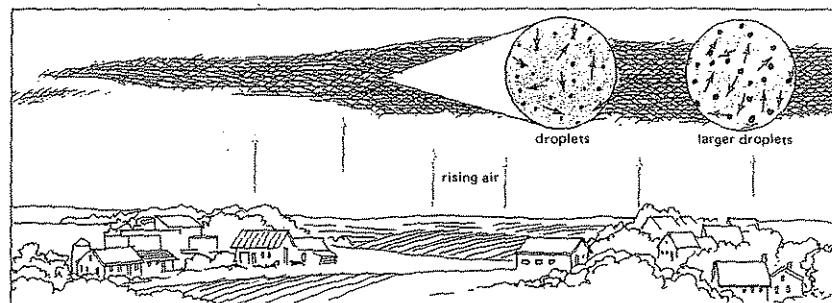


Figure A

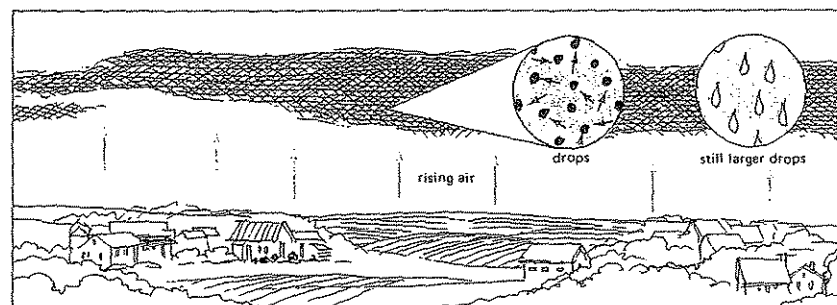


Figure B

1. A cloud is made up of billions of droplets of _____.
2. Droplets are very _____.
3. _____ keeps them from falling to earth.
4. Moving droplets _____. They join and become larger droplets.
5. The droplets collide _____.
6. The droplets become larger and heavier. They become the size of _____.

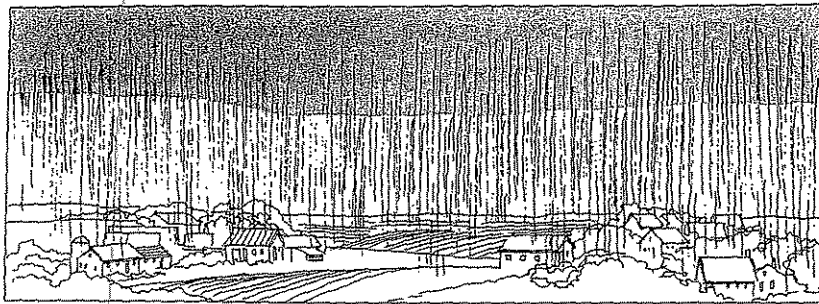


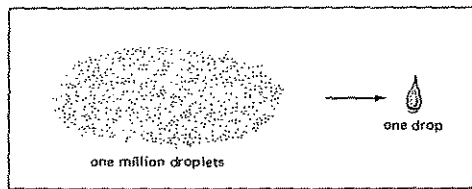
Figure C

7. Drops are much larger and _____ than droplets.
8. Rising air _____ hold them up.
9. The drops _____ to earth.
10. Water (in liquid or solid form) that falls to earth from clouds is called _____.

HOW BIG IS A DROP?

It takes about one million droplets to make just one drop.

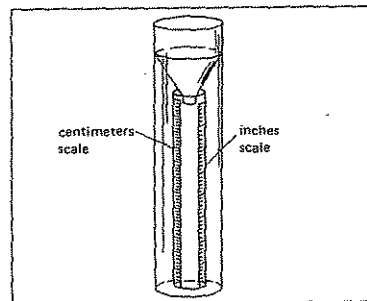
Figure D



A rain gauge tells us how much it has rained.

Rainfall is measured in inches or centimeters.

Figure E



HOW MUCH DOES IT RAIN?

The graph below shows about how many centimeters of rain fall on some American cities in one year. Study the graph. Then fill in the chart below the graph.

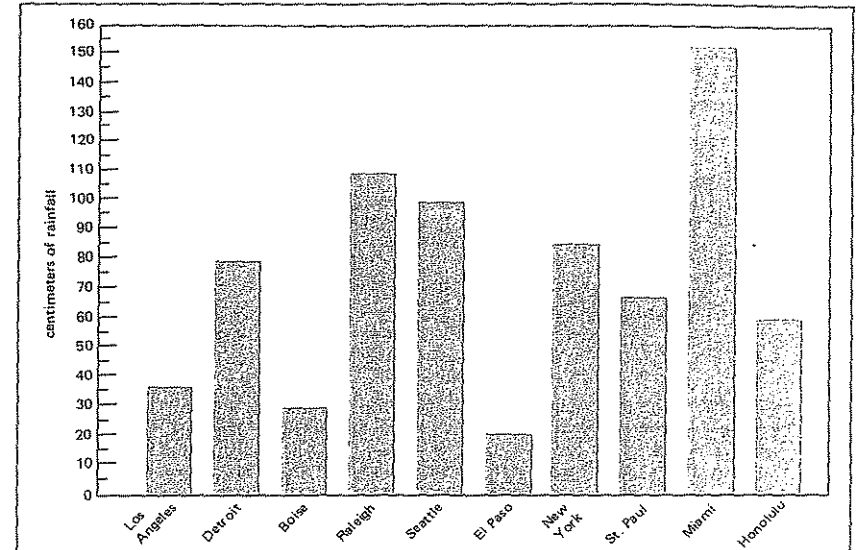


Figure F

	City	Average Yearly Precipitation (Approximate Centimeters)
1.	Boise (Idaho)	
2.	Detroit (Mich.)	
3.	El Paso (Texas)	
4.	Honolulu (Hawaii)	
5.	Los Angeles (Calif.)	
6.	Miami (Florida)	
7.	New York (N.Y.)	
8.	Raleigh (N.C.)	
9.	Seattle (Wash.)	
10.	St. Paul (Minn.)	

RECORD RAINFALLS

THE MOST



Figure G

In one year, 2,647 cm (1,042 inches) of rain fell in Cherrapunji, India.

THE LEAST

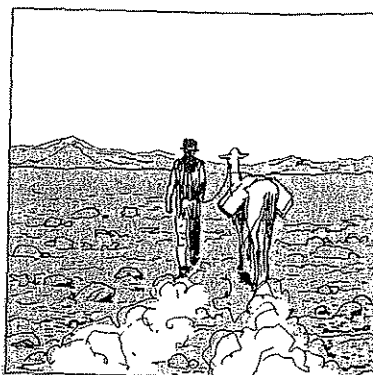


Figure H

In Arica, Chile, just .08 cm (.03 of an inch) fell over a period of 59 years. For 14 years in a row there was no rainfall at all!

TRUE OR FALSE Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

1. _____ Precipitation comes from clouds.
2. _____ About a million droplets make up a drop.
3. _____ Rain is the only kind of precipitation.
4. _____ Drizzle drops are bigger than raindrops.
5. _____ Sleet is liquid precipitation.
6. _____ Sleet and hail need freezing temperature.
7. _____ A barometer measures rainfall.
8. _____ Rainfall is measured in inches and centimeters.
9. _____ All places get the same amount of precipitation.
10. _____ We can live without precipitation.

COMPLETING SENTENCES

Complete the sentences with the choices below. Each choice may be used twice.

heavier
drizzle
drop
fall to the ground
sleet

hail
cloud
above freezing
rain
precipitation

freezing
rising air
snow
larger

1. A _____ is made up of billions of droplets of water.
2. Droplets are held in the air by _____.
3. When droplets collide, they become _____ in size.
4. About one million droplets make up a _____.
5. Drops are much _____ and _____ than droplets.
6. Drops _____.
7. Water in any form that falls to earth is called _____.
8. There are five kinds of precipitation. They are _____, _____, _____, _____, and _____.
9. It rains or drizzles when the temperature is _____.
10. It hails, sleet, or snows when the temperature is _____.

MATCHING

Match the two lists. Write the correct letter on the line next to each number.

- | | |
|------------------------|------------------------------|
| 1. _____ precipitation | a) like a fine spray |
| 2. _____ rain gauge | b) measures rainfall |
| 3. _____ vapor | c) change from gas to liquid |
| 4. _____ condensation | d) any water from the sky |
| 5. _____ drizzle | e) gas |

REACHING OUT

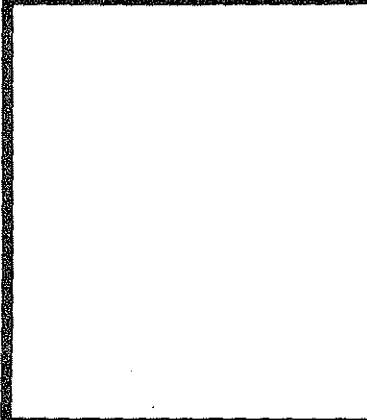
1. We cannot live without precipitation. Yet, precipitation can cause death and suffering. Explain. _____

2. How would you measure snowfall? _____

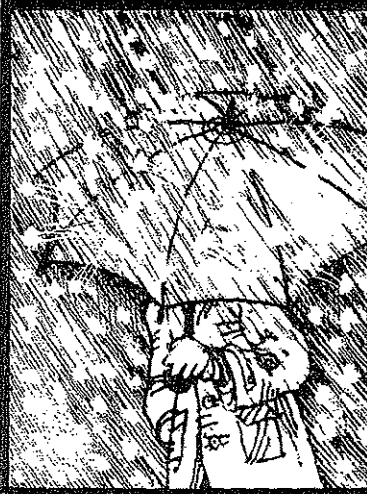
HOW DO SNOW, SLEET, AND HAIL FORM?

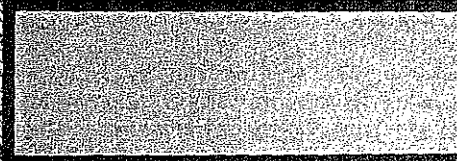


20









crystal: a solid that has a regular shape

Did you ever pack a snowball or make a snowman?

You cannot shape rain because rain is a liquid. Snow is different. Snow is a solid. It has a shape of its own. And we can change the shape of snow after it reaches the ground.

Snow is one kind of solid precipitation. There are two other kinds, sleet and hail. Each one forms in a different way. Let's study each one.

SNOW Water vapor condenses to form clouds.

If the temperature around the clouds is above freezing, the vapor changes to liquid droplets.

If, however, the temperature around the clouds is freezing, the vapor changes to tiny snow crystals.

The tiny snow crystals grow and grow. When they become heavy enough, they fall to earth. It snows.

SLEET Sleet is made of frozen raindrops.

Sometimes it is colder near the ground than it is up in the clouds. Rain falls from the clouds and goes through a layer of cold air before hitting the ground. This makes the raindrops freeze. The frozen raindrops fall to the earth as sleet.

HAIL Hail forms during some thunderstorms.

Strong air currents keep the raindrops moving in the air for a long time. As they move, they pass through many cold and warm layers of air.

In the cold air, the raindrops freeze. They change to icy beads. In the warm air, more water builds up around the beads. Then the water freezes when they pass through another cold layer.

This happens over and over again. Each time the icy beads become bigger. They become hailstones and fall to earth.

SLEET, SNOW, AND HAIL



Figure A



Figure B

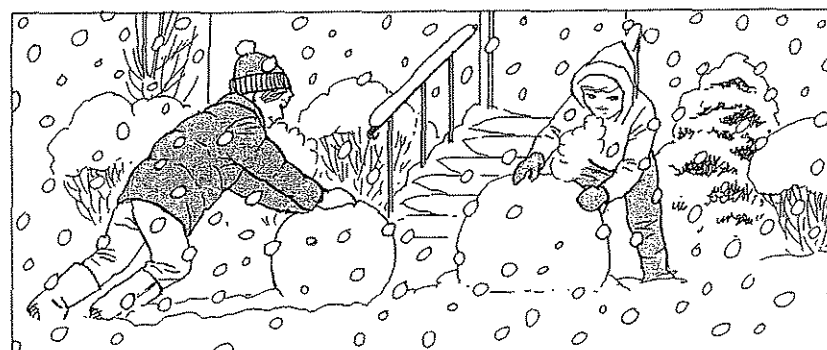


Figure C

Figure A shows rain falling.

1. The temperature around the clouds
is _____ freezing.
above, below

2. The temperature near the ground is _____ freezing.
above, below

Figure B shows sleet hitting the ground.

3. Sleet starts out as _____ .
ice, rain

4. The temperature around the clouds
is _____ freezing.
above, below

5. The temperature near the ground is _____ freezing.
above, below

Figure C shows snow falling.

6. The temperature around the clouds is _____ freezing.
above, below
7. Tiny snow _____ grow until they fall to earth.
drops, crystals

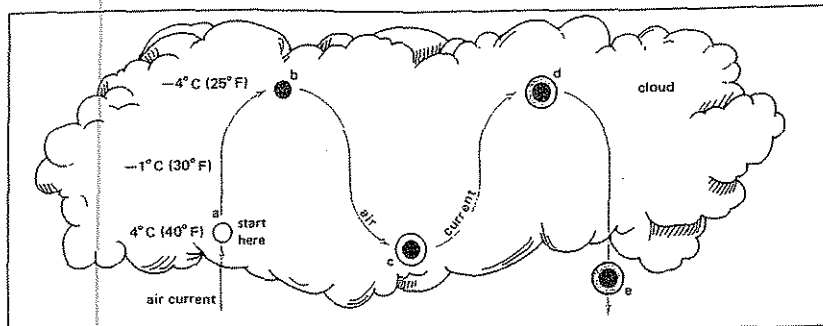


Figure D

Figure D shows how hail grows. Trace it step by step.

8. a) At a, the precipitation is _____
a liquid, a solid
- b) Air currents push it up to b. At b, it _____
changes to ice, is still a liquid
9. The ice drops to c. At c _____
more ice forms, water builds around the ice
10. a) Rising air pushes the ice up to d. At d the _____
added water freezes, ice melts
- b) The ice becomes _____
smaller, bigger
11. At e, the "bead" of ice is falling to earth. What has it become? _____

COMPLETING SENTENCES Complete the sentences with the choices below.

solid above precipitation
freezing liquid

1. Any form of water that falls from clouds is called _____.
2. Rain and drizzle are precipitation in the _____ state.
3. Snow, sleet, and hail are precipitation in the _____ state.
4. Rain and drizzle form in temperatures that are _____ freezing.
5. Snow, sleet, and hail form in _____ temperatures.

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|-----------------------|--------------------------------|
| 1. _____ water vapor | a) built-up ice beads |
| 2. _____ condensation | b) frozen raindrops |
| 3. _____ snow | c) change from vapor to liquid |
| 4. _____ sleet | d) falls as flakes |
| 5. _____ hail | e) water in the gas form |

SOME INTERESTING FACTS ABOUT SNOW AND HAIL

In the continental United States, the most snow falls in some places in California.



Figure E

152 centimeters (60 inches) fell in just one day in a place called Giant Forest.

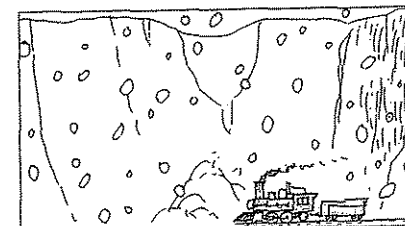


Figure F

2,245 centimeters (884 inches) fell in just one winter at Tamarack, California (1906-7). That's more than 22 meters (73 feet).

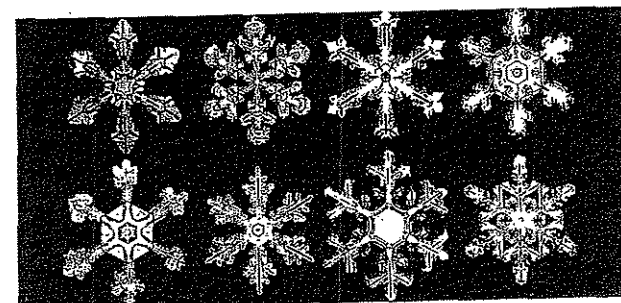


Figure G

Every snowflake has six sides or six points. BUT—no two snowflakes are exactly alike.

Can you imagine how many snowflakes have fallen since the earth was formed? Each one was different.

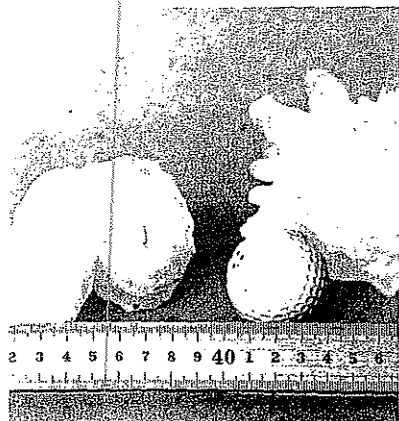


Figure H

Hailstones come in many sizes. They can be very big. Some are as large as marbles. Sometimes they are bigger than baseballs.

The largest hailstones fell in 1928 at Potter, Nebraska. They measured 43 centimeters (17 inches) around, and weighed .68 kilograms (1½ pounds).

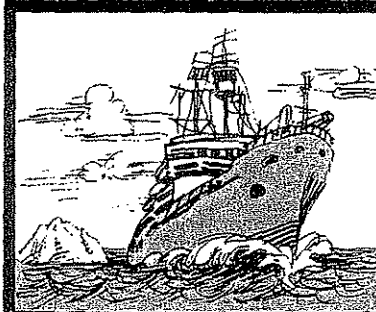
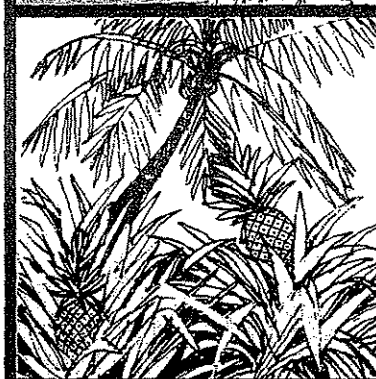


Figure I

Hail does a lot of damage in some parts of our country. It destroys crops and kills cattle.

WHAT IS AN AIR MASS?

21



air mass: a large body of air with about the same temperature and humidity throughout

continental: having to do with the land

maritime: having to do with the ocean

What will the weather be tomorrow? Is rain on the way? Will sunny weather be moving in?

Weather moves from place to place. But where does it come from? Where does weather start?

Most weather comes from **air masses**. An air mass is a huge body of air. It covers a very large area. Places within this area have about the same temperature and humidity.

An air mass starts over the ocean or over a large body of land. The air that makes up an air mass stalls over the water or land. It stands still for several days or weeks. During this time, the land or water gives the air its temperature and humidity. The air mass then moves on.

The humidity of air masses depends on where they form.

- Air masses that form over the ocean are called maritime [MA ri h time]. Maritime air is moist.

- Air masses that form over the land are called continental. Continental air is dry.

The temperature of air masses also depends on where they form.

- Air masses that form near the poles are called polar. Polar air is cold.

- Air masses that form near the tropics are called tropical. Tropical air is warm.

The name of an air mass has two parts:

(a) The first part tells us that it is either *maritime* or *continental*.

(b) The second part tells us that it is either *tropical* or *polar*.

For example, the name *continental tropical* tells us that the air mass formed over tropical land. The air would be dry and warm.

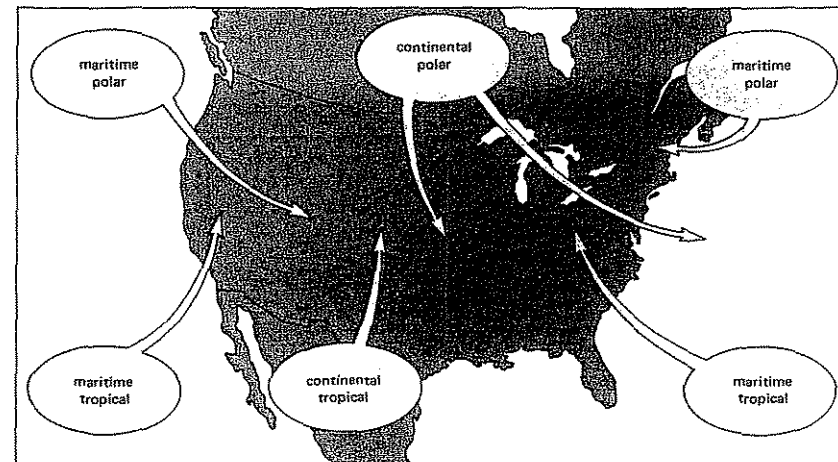


Figure A

The map (Figure A) shows the air masses that bring weather to North America. Study the map carefully. Then answer these questions.

1. Name the four kinds of air masses this map shows.

2. Which of these air masses move in from:

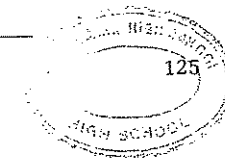
- a) the north? _____
- b) the south? _____
- c) the land? _____
- d) the ocean? _____

3. Which air mass brings

- a) cold and dry air? _____
- b) warm and dry air? _____

4. Which air masses bring

- a) cold and moist air? _____
- b) warm and moist air? _____



COMPLETING SENTENCES

Complete the sentences with the choices below.

very large area
humidity
warm
land

moist
air masses
continental
temperature

water
cold
the same
maritime

- Most weather comes from _____.
- An air mass covers a _____.
- The temperature and humidity in an air mass stay about _____.
- An air mass starts over a large body of _____ or _____.
- An air mass gets its _____ and _____ from the water or land it came from.
- The word that means "water" is _____.
- The word that means "land" is _____.
- The temperature of air that comes from the tropics is very _____.
- The temperature of air that comes from the poles is very _____.
- Air that comes from over the ocean is very _____.

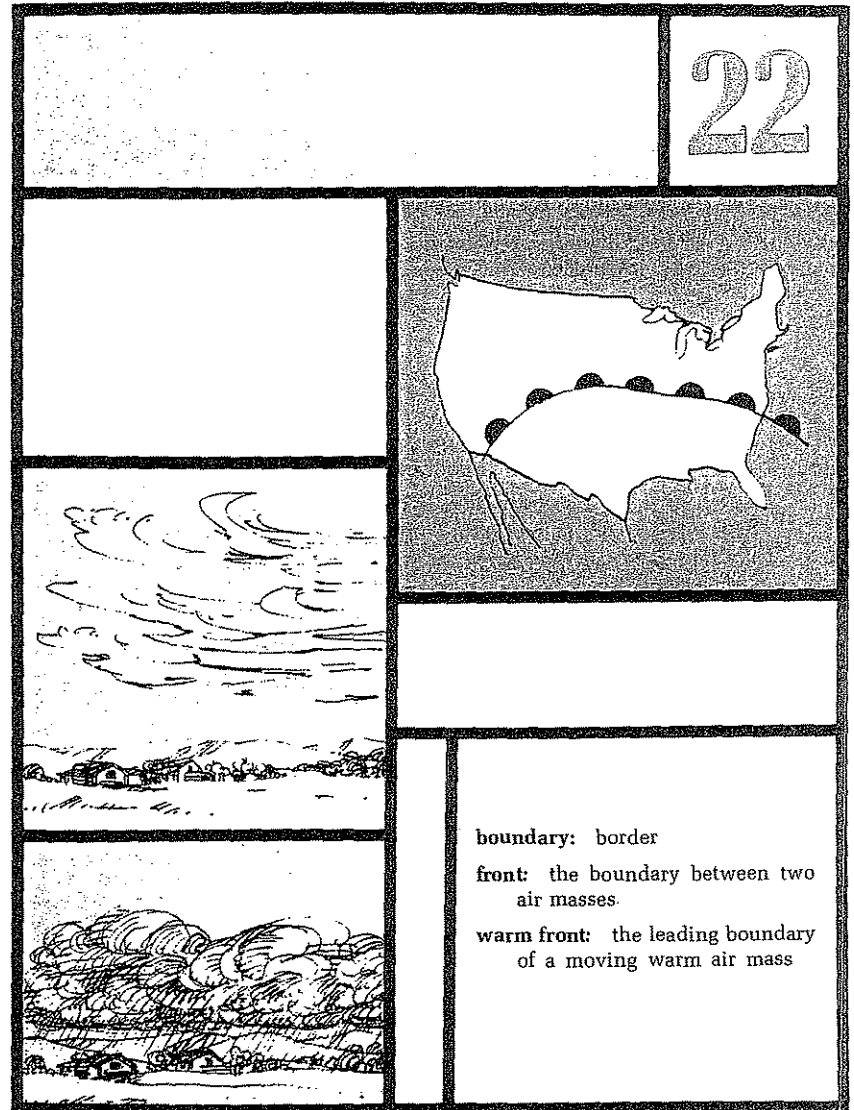
MATCHING

Match the air masses on the left with the weather on the right.

- | | |
|-------------------------------|-------------------|
| 1. _____ maritime polar | a) dry and warm |
| 2. _____ continental tropical | b) moist and warm |
| 3. _____ continental polar | c) moist and cold |
| 4. _____ maritime tropical | d) dry and cold |

WHAT HAPPENS WHEN AIR MASSES MEET?

22



Warm and cold air masses do not mix. When warm and cold air masses meet, they collide. The masses "battle" each other. The meeting causes many weather changes.

The boundary between two air masses is called a front. One kind of front is called a warm front.

A WARM FRONT FORMS WHEN A MOVING WARM AIR MASS PUSHES AGAINST A COLD AIR MASS.

The warm air of the front pushes upward. It flows over the top of the cooler air mass.

Many clouds form along a warm front. They may reach out for 1,600 kilometers (1,000 miles) or more.

At first there are only thin cirrus clouds high in the sky. Then stratus clouds move in. Slowly, the clouds become lower and lower. Finally, it rains. If the temperature is low enough, it snows.

Precipitation along a warm front is even and steady. It keeps falling until the front passes. It may last a few days. Then the weather becomes clearer and warmer.

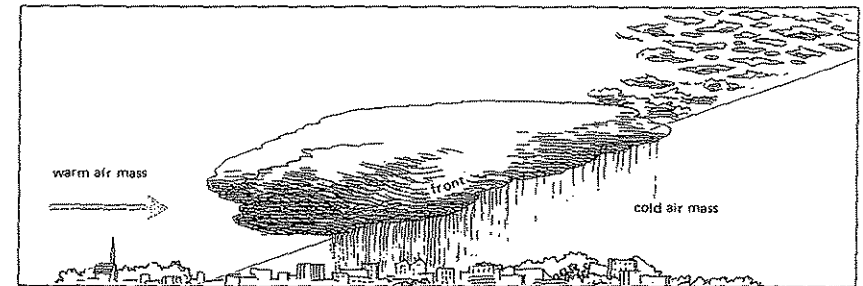


Figure A

Figure A shows a warm front. Find the two air masses. The warm air pushes upward and flows over the cold air. Many clouds form where the two air masses meet.

See for yourself how a warm front brings weather changes slowly.

1. Get a thin piece of paper. Tracing paper would be best.
2. Put your paper over Figure B and trace it.
3. Now put the traced drawing over Figure C, lining up the x's.
4. Slowly, move the tracing to the right over Figure C until the y's match up.

Now imagine yourself to be at spot y. What would you see? What would you feel?

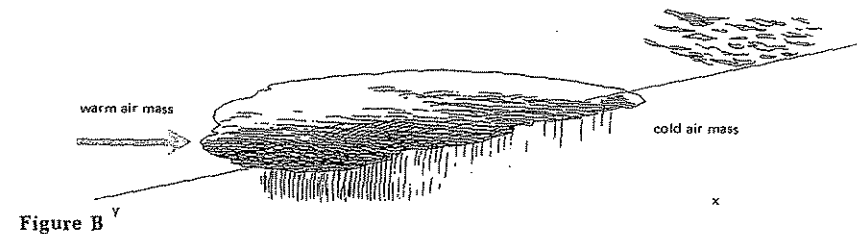


Figure B



Figure C

WARM FRONT ON A WEATHER MAP

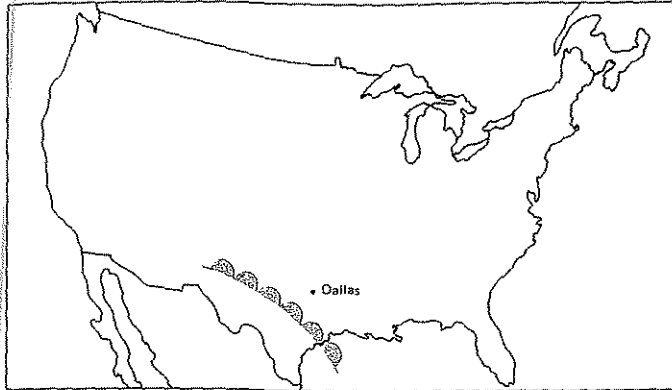


Figure D

The symbol for a warm front is . Figure D shows what it looks like on a weather map.

The warm front on this map is moving towards Dallas. Its speed is about 24 kilometers (15 miles) per hour. Dallas is 240 kilometers away.

In how many hours will the warm front reach Dallas? _____

COMPLETING SENTENCES

Complete the sentences with the choices below.

darker	boundary	"battle each other"
many weather changes	lower	clear and warmer
front passes	warm front	clouds
rain or snow		

1. A front is the _____ between two air masses.
2. When warm air and cold air meet, they _____.
3. A front brings about _____.
4. A warm air mass that pushes a cold air mass is called a _____.
5. A warm front forms many _____.
6. The clouds along a warm front slowly become _____ and _____.

7. A warm front brings steady and even _____.
8. Precipitation along a warm front continues until the _____.
9. After a warm front passes, the weather becomes _____.
10. The symbol for a warm front is _____.

FIND THE PARTS

Figure E shows a warm front.

Find the parts listed below. Write the correct letter on each space and fill in the blanks.

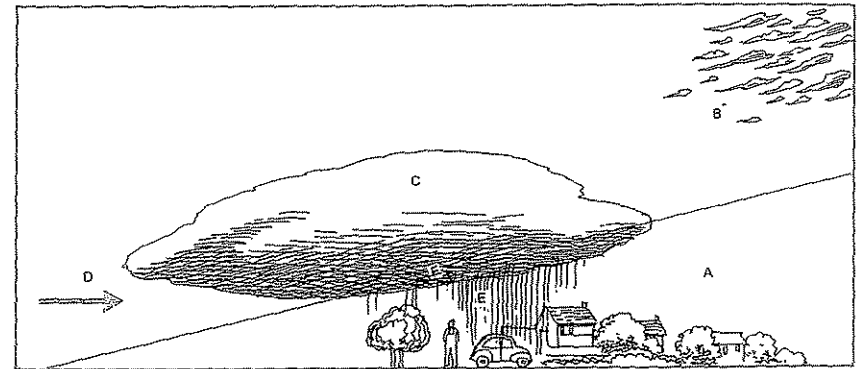


Figure E

1. warm air mass _____
2. cold air mass _____
3. warm front _____
4. cirrus clouds _____
5. stratus clouds _____
6. area of precipitation _____
7. The warm front is moving from _____
left to right, right to left
8. A warm front changes weather _____
slowly, quickly
9. Usually, precipitation from a warm front lasts _____
only a few hours, several days
10. After the warm front passes, the weather becomes _____
colder, warmer

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | | |
|----------|---|------------------------------------|
| 1. _____ | warm front | a) boundary between two air masses |
| 2. _____ | cold air and warm air | b) kinds of precipitation |
| 3. _____ |  | c) pushes against a cold air mass |
| 4. _____ | rain and snow | d) do not mix easily |
| 5. _____ | front | e) warm front symbol |

TRUE OR FALSE Write T on the line next to the number if the sentence is true. Write F if the sentence is false.

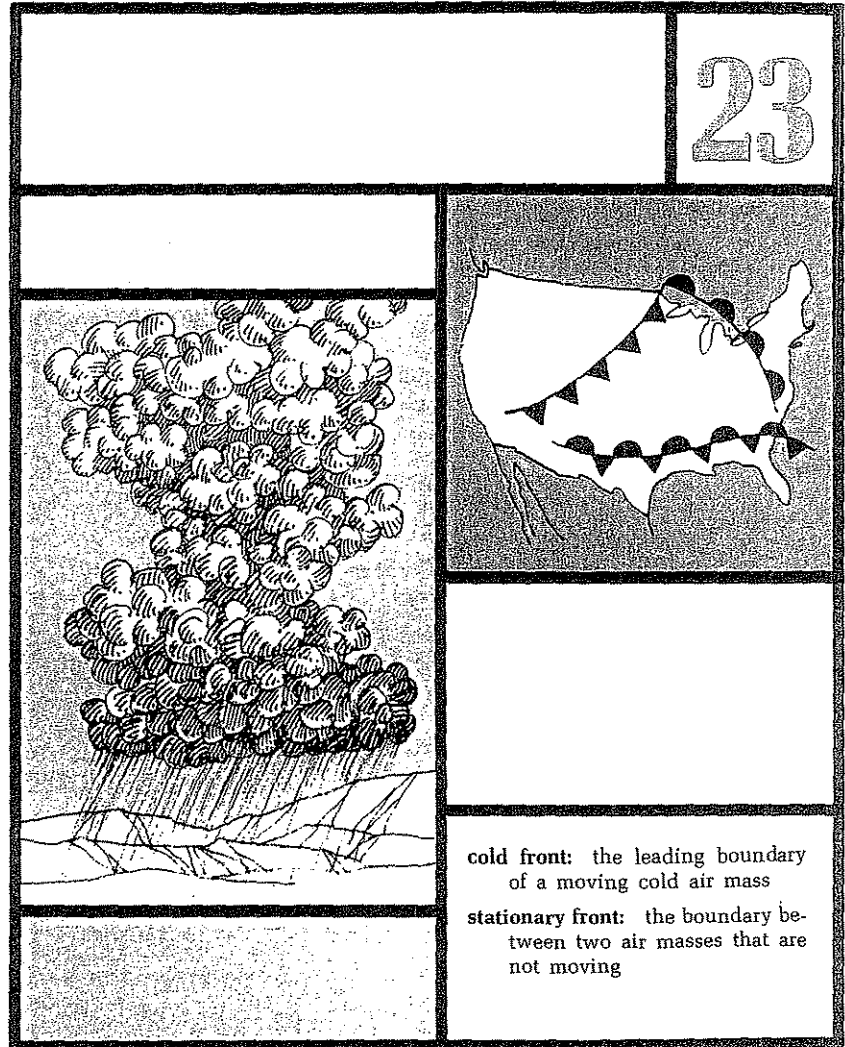
1. _____ Warm and cold air masses mix easily.
2. _____ The border between air masses is called a front.
3. _____ In a warm front, warm air pushes against cold air.
4. _____ A warm front brings many clouds.
5. _____ A warm front causes fast weather changes.
6. _____ The first clouds you see along a warm front are stratus clouds.
7. _____ The last clouds you see along a warm front are stratus clouds.
8. _____ Cirrus clouds are rain clouds.
9. _____ Cirrus clouds warn of coming rain or snow.
10. _____ Precipitation along a warm front lasts a few hours.

REACHING OUT

A passing warm front changes air pressure. Does a passing warm front increase or decrease air pressure? (Hint: In Aim 5, you learned how temperature changes the weight of air.)

WHAT IS A COLD FRONT? WHAT IS A STATIONARY FRONT?

23



AIM | What is a cold front?

23 | What is a stationary front?

COLD FRONT

A warm front changes weather slowly.

Another kind of front, called a *cold front*, changes weather quickly.

A COLD FRONT FORMS WHEN A MOVING COLD AIR MASS PUSHES AGAINST A WARM AIR MASS.

A moving cold front "scoops up" warm air that it meets. It lifts the warm air high into the atmosphere. The warm air condenses. Tall storm clouds form. Strong winds blow. Heavy rain or snow falls. But it lasts only a few hours. A short time after the cold front passes, the weather becomes clearer and drier. The temperature drops suddenly. In the wintertime, a cold front may bring very cold air.

STATIONARY FRONT

Sometimes a cold and warm mass meet, but then stop moving. The boundary between air masses that have stopped moving is called a *stationary* [STAY shuh ner ee] front.

A stationary front may remain only for a short time. Then there is little weather change.

If a stationary front remains for a long time, the weather changes. Warm front-like weather takes over. There is a steady rain. It may last a few days. Then the sky clears and it becomes warmer.

WHAT A COLD FRONT LOOKS LIKE

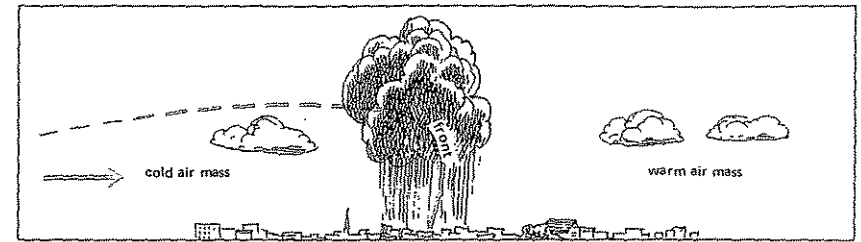


Figure A

Figure A shows a cold front. Find the two air masses. The moving cold air pushes the warm air high up. Many storm clouds form.

See for yourself the rapid weather changes a cold front brings.

What To Do

1. Get a thin piece of paper. Tracing paper would be best.
2. Put your paper over Figure B and trace it.
3. Now put the traced drawing over Figure C, lining up the x's.
4. Slowly, move the tracing to the right over Figure C until the y's match up.

Now imagine yourself to be at spot y. What would you see? What would you feel?

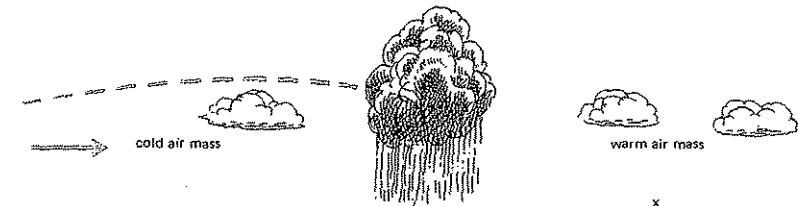


Figure B



Figure C

MORE WEATHER MAP SYMBOLS

The symbol for a cold front is .

The symbol for a stationary front is .

Figure D shows what these symbols look like on a weather map.

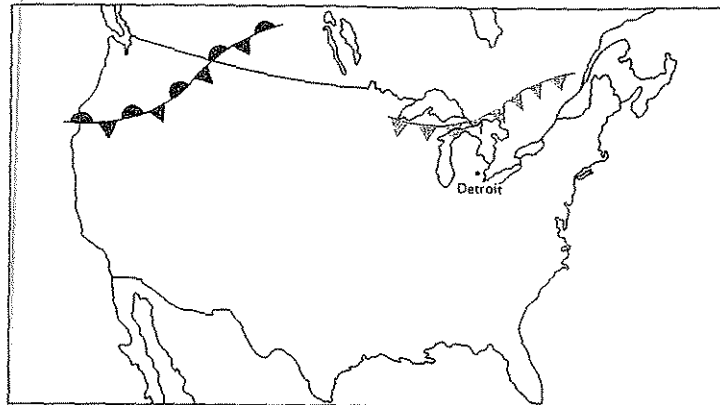


Figure D

The cold front on this map is moving towards Detroit. Its speed is about 40 kilometers (25 miles) per hour.

Detroit is 440 kilometers away.

In how many hours will the cold front reach Detroit? _____

COMPLETING SENTENCES Complete the sentences with the choices below.

storm clouds
for a long time
drops suddenly
cold front

for a short time


heavy snow or rain
does not
stationary front

- When a cold air mass pushes against a warm air mass, a _____ is formed.
- A cold front produces big _____.
- Cold front clouds bring sudden _____.
- Precipitation from cold front clouds _____ last a long time.

- When a cold front passes, the temperature _____.
- The symbol for a cold front is _____.
- The border between "stalled" air masses is called a _____.
- Little weather change happens if a stationary front stops _____.
- Warm-front weather follows if a stationary front stops _____.
- The symbol for a stationary front is _____.

FIND THE PARTS Figure E shows a cold front. Find the parts listed below. Write the correct letter in each space and fill in the blanks.

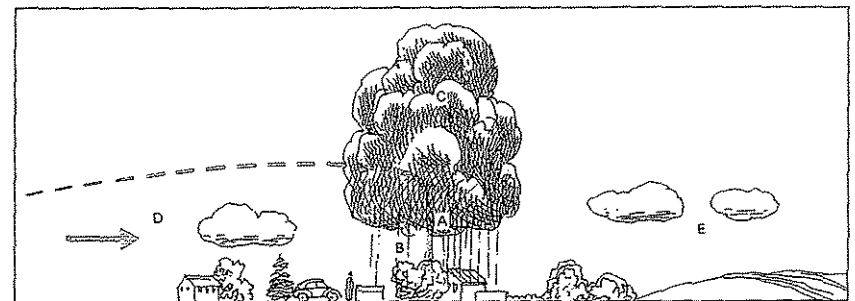


Figure E

- warm air mass _____
- cold air mass _____
- cold front _____
- storm clouds _____
- area of precipitation _____
- The cold front is moving from _____
right to left, left to right
- Look at the slope (slant) of the front. The slope of a cold front is _____
gentle, steep
- A cold front changes weather _____
slowly, quickly
- Precipitation from a cold front lasts _____
only a few hours, a long time
- Tall storm clouds (thunder clouds) _____ form along a cold front.
may, usually do not

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | | |
|----------|---|----------------------------------|
| 1. _____ |  | a) symbol for a stationary front |
| 2. _____ |  | b) caused by a warm front |
| 3. _____ |  | c) symbol for a cold front |
| 4. _____ | slow weather changes | d) caused by a cold front |
| 5. _____ | rapid weather changes | e) symbol for a warm front |

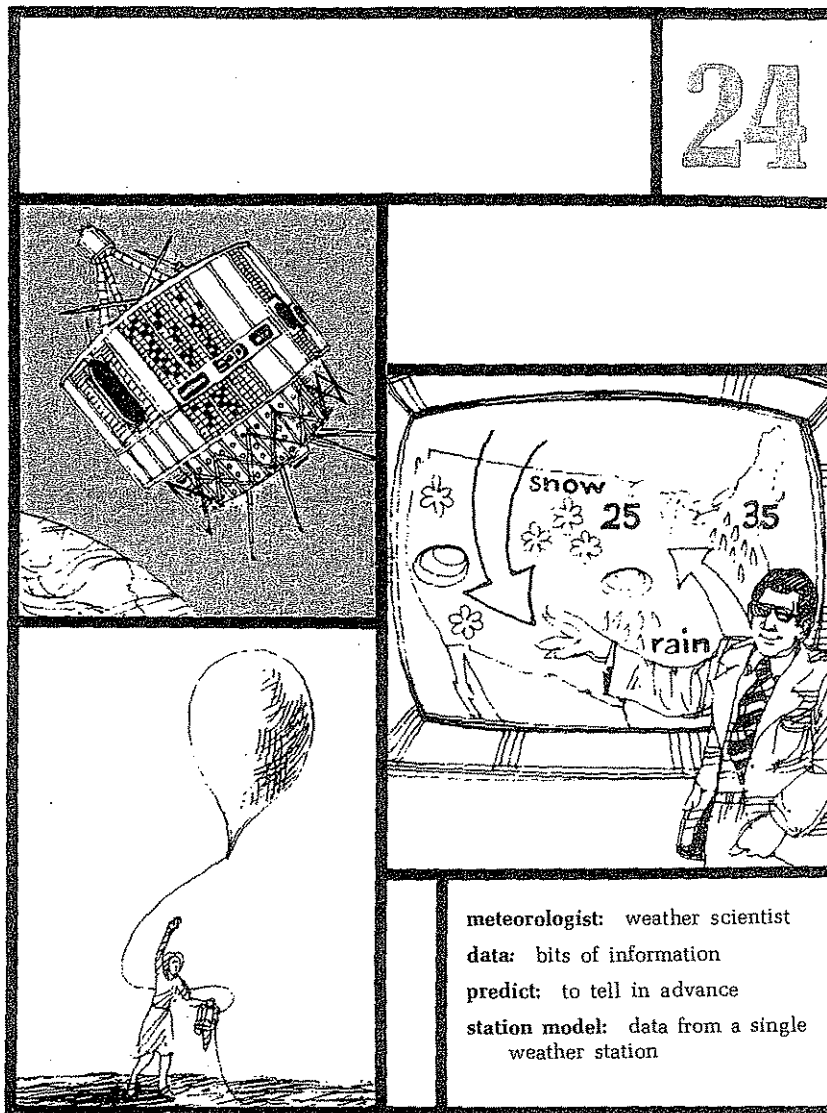
TRUE OR FALSE Write T on the line next to the number if the sentence is true. Write F if the sentence is false.

1. _____ A moving cold front moves cold air over warm air.
2. _____ A cold front has a gentle slope.
3. _____ A cold front always brings snow.
4. _____ A cold front builds storm clouds.
5. _____ A cold front brings slow weather changes.
6. _____ Precipitation along a cold front lasts a short time.
7. _____ "Stationary" means moving.
8. _____ A stationary front is a front that is not moving.
9. _____ A stationary front never moves.
10. _____ A stationary front can bring clear and warm weather.

REACHING OUT A passing cold front changes air pressure. Does a passing cold front increase or decrease air pressure? (Hint: Think how temperature changes the weight of air.)

HOW DO WE FIND OUT ABOUT THE WEATHER?

24



AIM | How do we find out about 24 | the weather?

You stand at your window and look outside. The sky is gray. It's raining "cats and dogs." Yet, the weather report predicts sunny weather. It doesn't seem possible!

A little time passes and, sure enough, the sky starts to clear. Soon, the sun breaks through. It's a beautiful day! The weather reporter's prediction has come true.

How does the weather reporter know what the weather will be?

Predicting weather is not a simple job. It takes teamwork by hundreds of weather scientists. A weather scientist is called a meteorologist [mee tee uh RAH luh jist].

Many meteorologists work for the United States Weather Service. The Weather Service has more than 600 weather stations. They are spread over the country. Some are even outside the country. Each station has all the weather instruments you have learned about.

The meteorologists read the instruments four times a day. They mark down the temperature, humidity, air pressure, wind speed, and wind direction. If there is any rain or snow they mark that down, too.

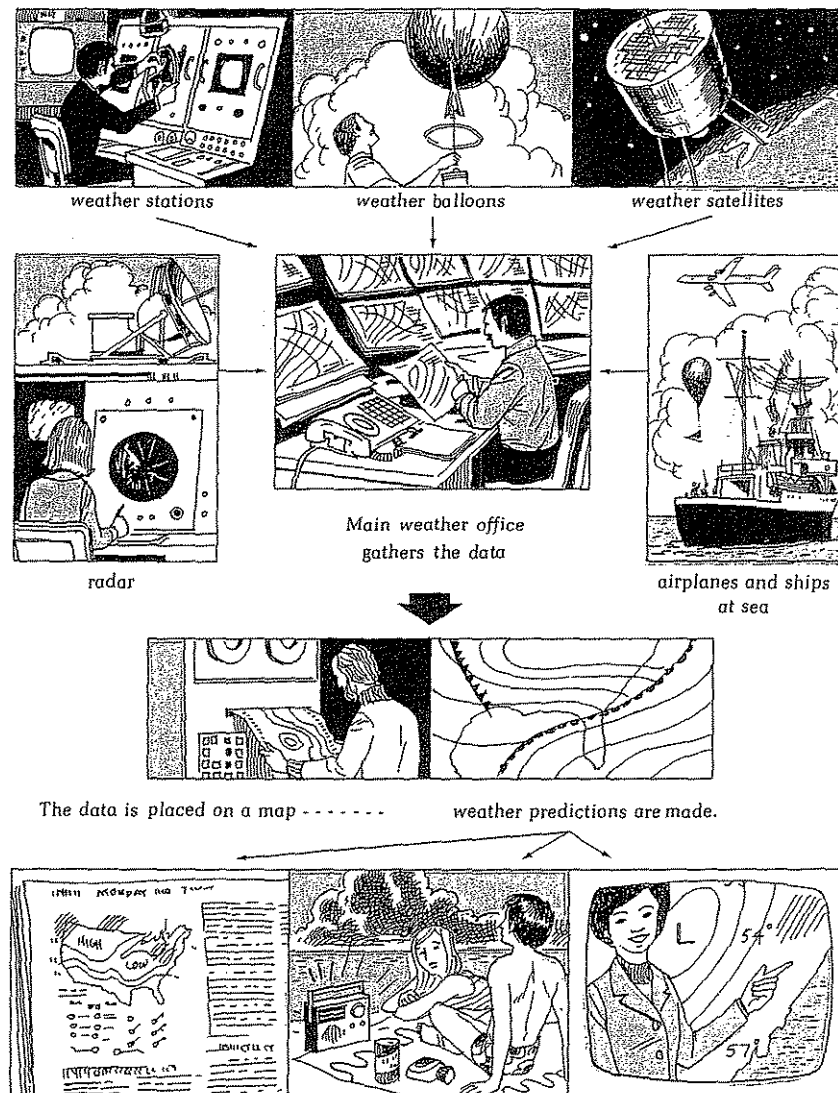
The weather scientists also look at the sky. They mark down the kind of clouds they see and how high they are.

All this data is put into a number code. It is sent to a main station. Here, the data is put on a master map. The data describes the air masses in different places. By knowing how fast and in what direction air masses are moving, meteorologists can make predictions. Sometimes, computers help make predictions.

Weather predictions aren't always right. But they are about 80 to 90 percent right. And that's a pretty good record!

SOURCES OF WEATHER DATA

Not all weather data comes from weather stations. The picture chart below shows other sources of weather data. It also shows what happens to the data after it is collected.



Predictions are sent to many places. They include newspapers, radio stations, and television stations.

STATION MODELS

Figure A shows what the data from a weather station looks like.

It is called a station model.

The number code and symbols are a short-cut way of writing the data.

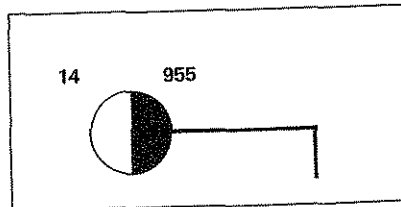


Figure A

Station models from the hundreds of weather stations are used to make a map like Figure B.

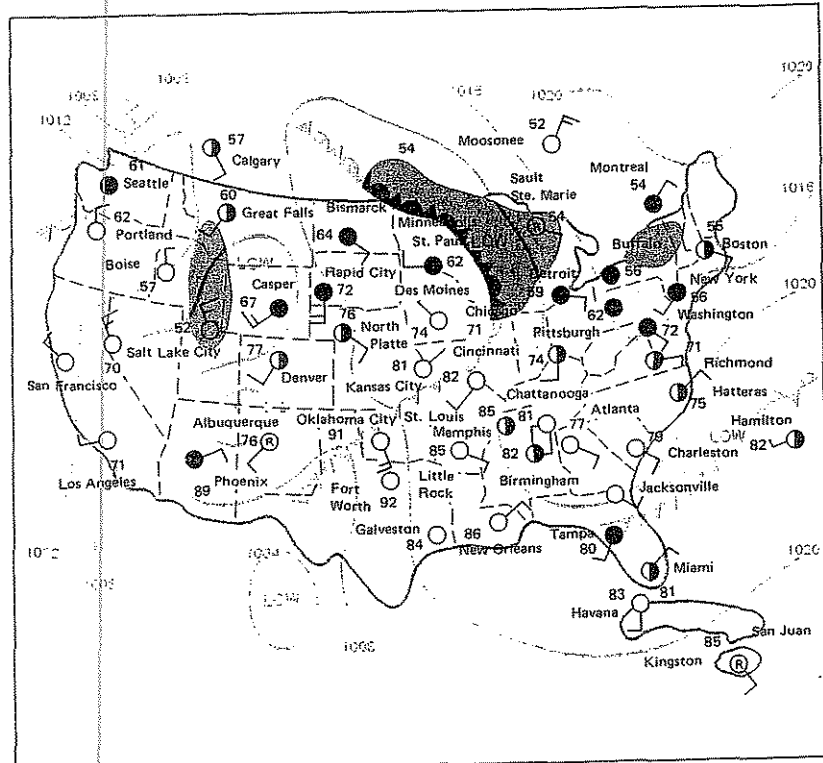


Figure B

Get ready for a surprise! In the next Aims you will be making maps like this!

COMPLETING SENTENCES Complete the sentences with the choices below.

predict weather
meteorologist
weather satellites
six hundred
airplanes and ships

station model
weather balloons
four times a day
weather map

radar
U.S. Weather Service
code
weather instruments

1. A weather scientist is called a _____.
2. In the United States, gathering weather data and predicting weather is the job of the _____.
3. The Weather Service operates more than _____ weather stations.
4. Every weather station has _____.
5. Weather station instruments are checked _____.
6. Weather data is sent to a main station in _____ form.
7. The data from a single weather station is called a _____.
8. Meteorologists use all the station models to make a master _____.
9. A weather map helps us to _____.
10. Much weather data comes from weather stations. Weather data also comes from _____, _____, _____ and _____.

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|-------------------------------------|---------------------------------------|
| 1. _____ meteorologist | a) weather data from a single station |
| 2. _____ barometer | b) number of U.S. Weather Stations |
| 3. _____ station model | c) a weather instrument |
| 4. _____ more than 600 | d) example of weather data |
| 5. _____ NE, 25 kilometers per hour | e) weather scientist |

TRUE OR FALSE Write T on the line next to the number if the sentence is true.
Write F if the sentence is false.

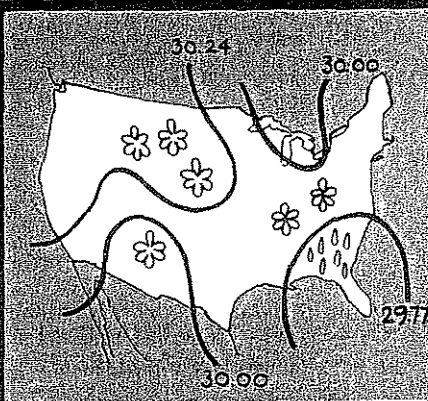
1. _____ A weather scientist is called a meteor.
2. _____ Only a meteorologist can predict weather.
3. _____ You can learn to predict weather.
4. _____ Predicting weather in the United States is the job mainly of the U.S. Weather Service.
5. _____ There are 60 U.S. Weather Service weather stations.
6. _____ U.S. Weather Service stations are only in the United States.
7. _____ Some weather information comes from ships at sea, airplanes, satellites, and radar.
8. _____ In a way, your eyes can be called weather instruments.
9. _____ A weather station gets its information only from instruments.
10. _____ Most weather predictions are correct.

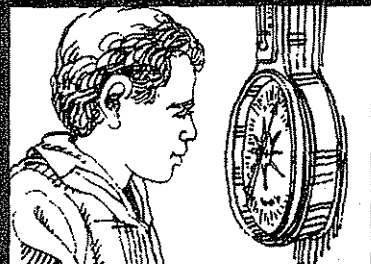
REACHING OUT Why are weather predictions becoming more and more accurate?

WHAT IS AN ISOBAR?

25







millibar: a unit of air pressure

isobar: a line on a weather map that joins places that have the same air pressure

hurricane: a tropical storm

tornado: a small but destructive storm

AIM | What is an isobar?

25

A weather map shows us weather conditions from many places. How is air pressure shown on a map?

Air pressure is measured in units called millibars [MIL i barz]. The numbers in Figures A, C, and D are in millibars.

An isobar [ICE oh bar] is a special line on a weather map. It joins places that have the same air pressure. Notice how the numbers on millibars in Figures A and C are joined by isobars. An isobar follows a curved path. The ends meet to form a closed figure.

Look at the isobars in the west in Figure C. The numbers become larger toward the center. The isobars show a high-pressure area.

Dry air weighs more than moist air. The more the air weighs, the higher the pressure is. Weather in a high-pressure area is generally dry and fair. A high-pressure area is shown by H.

Now look at the isobars in the east in Figure C. The numbers become smaller toward the center. The isobars show a low-pressure area.

Moist air weighs less than dry air. The less the air weighs, the lower the pressure is. The weather in a low-pressure area is generally cloudy or rainy. A low-pressure area is shown by L.

HOW TO DRAW ISOBARS

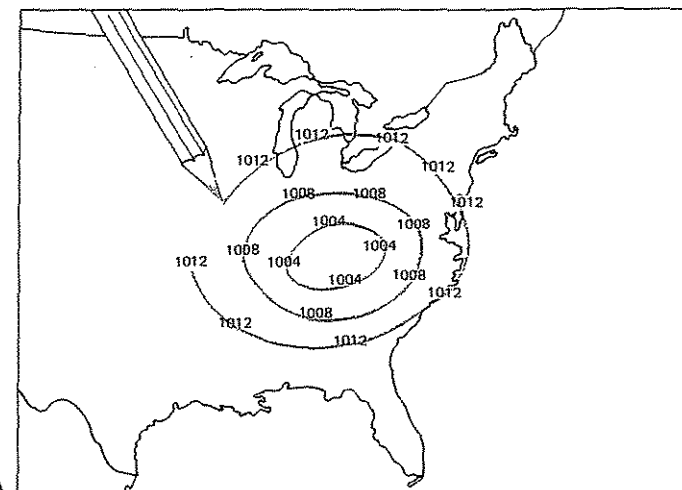


Figure A

FIRST, mark the air pressure readings on the map. (The numerals stand for millibars.)

THEN, draw a line through places of equal pressure. (They have the same millibar numerals.)

1. How many isobars does Figure A have? _____

2. a) How many different pressure numbers are shown? _____

List them. _____

b) Which number shows the highest pressure? _____

c) Which number shows the lowest pressure? _____

3. a) Is this a high- or low-pressure area? _____

b) Mark the kind of pressure area on Figure A.

4. How many weather stations helped make this map possible? _____

5. Name the instrument that measures air pressure. _____
(Look back to Aim 5 if you have to.)

MARKING MILLIBARS

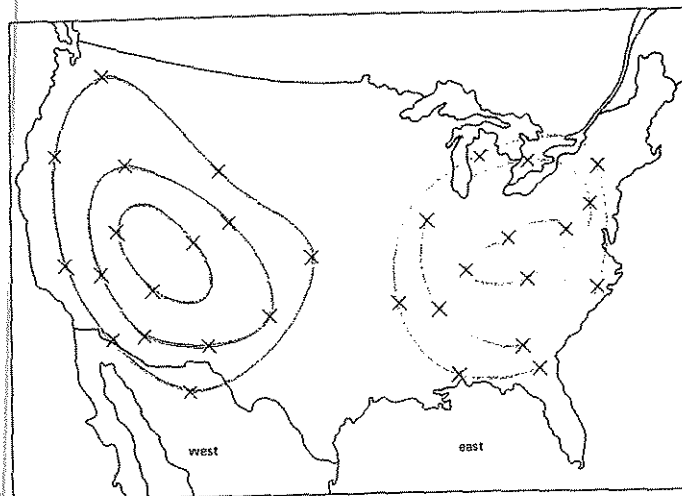


Figure B

Figure B shows two large pressure areas. One is in the east; the other in the west. Each pressure area has three isobars. There are x's along each isobar.

WEST

1. Mark the air pressure on the x's along each isobar.

Start with the outside isobar.

1022 millibars
1026 millibars
1030 millibars

Now answer these questions.

2. As you go towards the center, the pressure becomes _____.
3. This is a _____ pressure area. Label it in the proper way.
4. The weather in this area is probably _____.

fair, cloudy

EAST

5. Mark the air pressure on the x's along each isobar.

Start with the outside isobar.

1008 millibars
1004 millibars
1000 millibars

Now answer these questions.

6. As you go towards the center, the pressure becomes _____.
7. This is a _____ pressure area. Label it in the proper way.
8. The weather in this area is probably _____.

fair, cloudy

"READING" ISOBARS

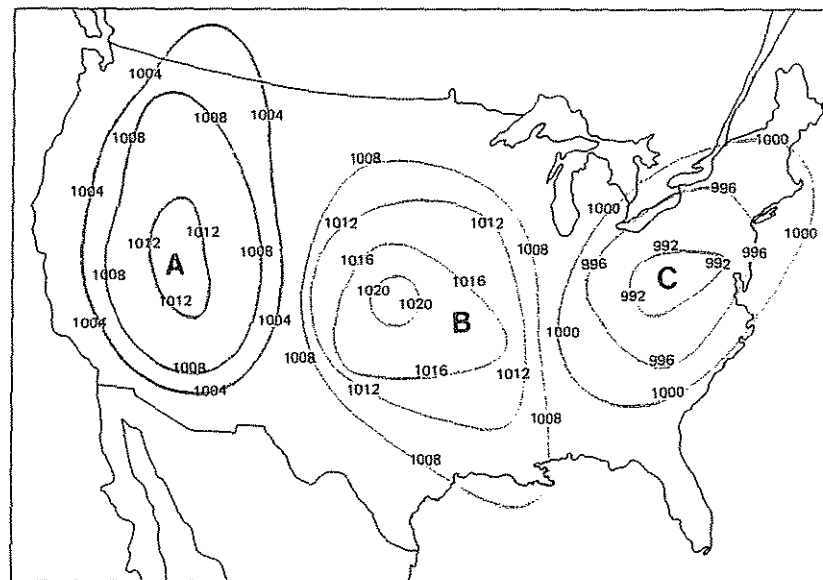


Figure C

Figure C shows three pressure areas, A, B, and C. Study each one. Then answer these questions.

1. Area A is a _____ pressure area.
2. The weather in area A is probably _____.
3. Area B is a _____ pressure area.
4. The weather in B probably is _____.
5. Area C is a _____ pressure area.
6. The weather in C probably is _____.
7. Write the proper symbol in the middle of each pressure area.

MAKING ISOBARS

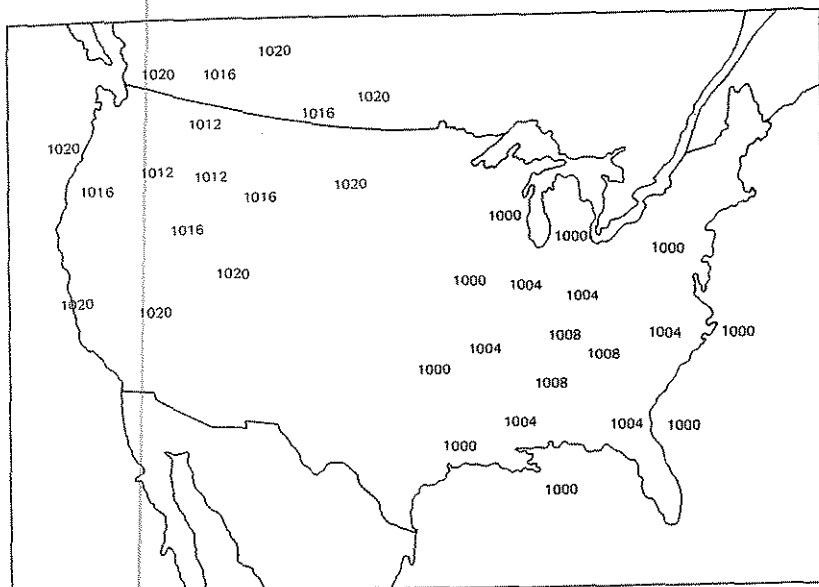


Figure D

Figure D has barometer readings of two pressure areas. One area is in the west. The other is in the east.

Follow the directions. Then fill in the blanks.

1. Study each set of readings. Then draw isobars.
2. Label each pressure area with an H or L.
3. The high-pressure area is in the _____ east, west.
4. The low-pressure area is in the _____ east, west.
5. The weather in the east is probably _____ fair, cloudy.
6. The weather in the west is probably _____ fair, cloudy.

SPECIAL LOW-PRESSURE AREAS

HURRICANES

Sometimes a very low-pressure area forms over the ocean near the equator. A tropical air mass picks up a lot of moisture from the warm waters. Such low pressure causes very strong winds and heavy rain. When such a powerful storm forms over the Atlantic Ocean, it is called a hurricane.



Figure E

A hurricane moves in a wide circular path. Sometimes it reaches land and causes much destruction. Winds can reach close to 325 kilometers per hour (200 mph). Rains can cause flooding.

In 1969, hurricane Camille killed close to 300 people in the southern United States. It caused about half a billion dollars worth of damage to property.

A similar storm (called a typhoon) in Bangladesh killed close to half a million people in 1970.

TORNADOES

The most violent kind of storm is a tornado. It looks like a dark, curving funnel reaching down from a black cloud. It is a small storm and lasts only a short time. But in its path it causes tremendous destruction.

Its low pressure causes winds up to 800 kilometers per hour (500 mph). It blows down buildings and trees. It tumbles automobiles and trucks. It often picks up and carries people hundreds of feet.

The worst tornado in history happened March 18, 1925. This "twister" was much larger and faster than most.

It killed 689 people as it roared across parts of Missouri, Illinois, and Indiana.



Figure F

REACHING OUT

Make a complete isobar map.

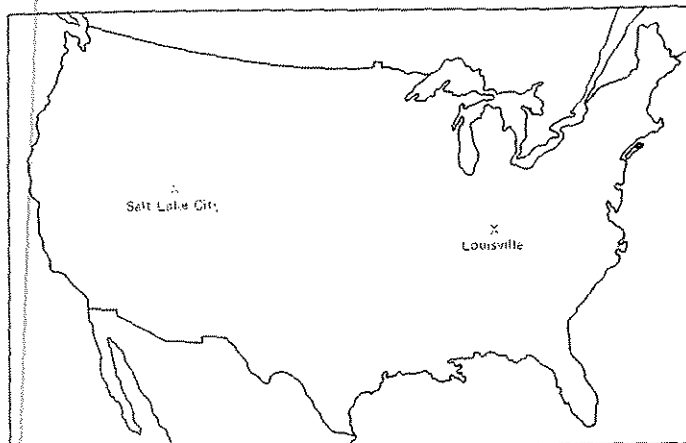


Figure G

Draw two pressure areas.

Write in the pressure readings on the map. Then draw the isobars.

1. a) Draw a high-pressure area over Salt Lake City.

- b) Use the millibar readings listed below. But first, separate them. Put them in proper order to show high pressure.

1024 1020 1028 1020 1024 1024 1020 1028 1020 1024 1028 1020

2. a) Draw a low-pressure area over Louisville.

- b) Use the millibar readings listed below. But first, separate them. Put them in proper order to show low pressure.

996 1004 1000 1004 1000 1004 996 1004 1000 996 1000 1004

HOW DO WE SHOW SKY CONDITION AND TEMPERATURE ON A WEATHER MAP?

26

○ CLEAR	⊙ RAIN
◐ PARTLY CLOUDY	⊞ SNOW
● CLOUDY	⊖ FOG

ball symbols: circles on a weather map that gives us sky information

AIM 26

How do we show sky condition and temperature on a weather map?

SKY CONDITION What is this? ○ A circle? A large letter O? Yes, but is is also a weather symbol for a weather map. It stands for clear sky.

The condition of the sky is shown by a ball symbol.

Ball symbols tell us if the sky is clear, cloudy, or partly cloudy.

In most weather maps you see, the ball symbol also shows precipitation.

The ball of the "clear sky" symbol has nothing in it. All other sky symbols have something in the ball.

These are the ball symbols. They are simple to memorize. You probably can do it in a minute or two.

- | | |
|-----------------|---|
| ○ clear | Ⓩ freezing rain (sleet or hail) |
| ◐ partly cloudy | Ⓢ snow |
| ● cloudy | Ⓣ thunderstorms |
| ⓕ fog | Ⓜ missing (information not sent by the weather station) |
| Ⓡ rain | ☙ hurricane |

TEMPERATURE It's very easy to show temperature on a weather map. Just write the temperature near the city. THAT'S ALL! Easy enough?

This is what "partly cloudy" sky with 20°C temperature looks like:

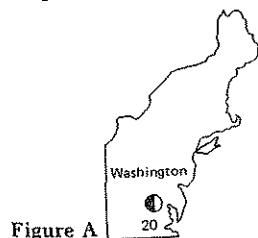


Figure A

DRAWING BALL SYMBOLS

Draw the ball symbol for each of the following: (Cover the Aim page.)

	Sky Condition	Symbol		Sky Condition	Symbol
1.	fog		6.	snow	
2.	hail or sleet		7.	hurricane	
3.	information missing		8.	partly cloudy	
4.	fog		9.	thunderstorms	
5.	clear		10.	cloudy	

IDENTIFYING BALL SYMBOLS

What do these symbols mean?

	Symbol	Meaning		Symbol	Meaning
1.	Ⓩ		6.	☙	
2.	Ⓜ		7.	ⓕ	
3.	Ⓣ		8.	Ⓡ	
4.	○		9.	◐	
5.	●		10.	Ⓢ	

WEATHER MAP

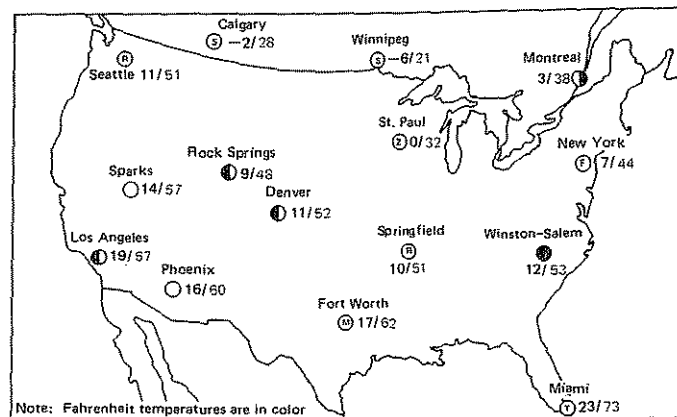


Figure B

The weather map (Figure B) shows the sky conditions and temperatures of fifteen cities. Use this weather map to fill in the chart.

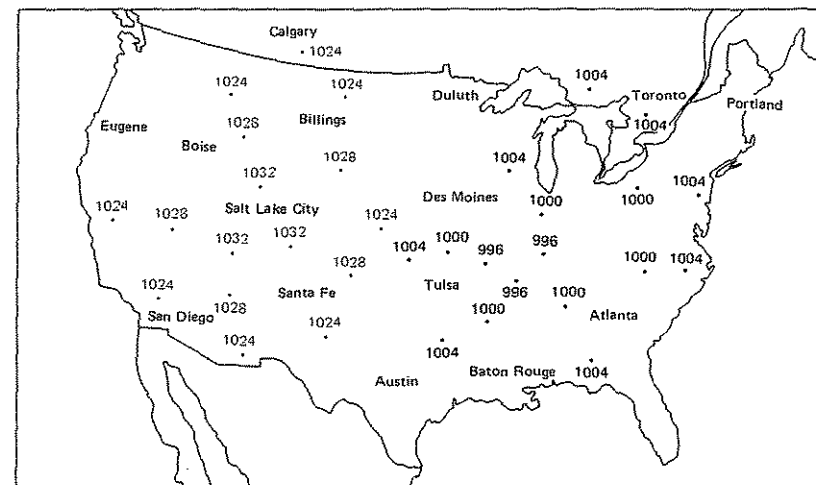
	City	Sky Condition	Temperature (°C)
1.	Calgary, Alta.		
2.	Denver, Colo.		
3.	Fort Worth, Texas		
4.	Los Angeles, Calif.		
5.	Miami, Fla.		
6.	Montreal, Que.		
7.	New York, N.Y.		
8.	Phoenix, Ariz.		
9.	Rock Springs, Wyo.		
10.	Seattle, Wash.		
11.	Sparks, Nev.		
12.	Springfield, Ohio		
13.	St. Paul, Minn.		
14.	Winnipeg, Man.		
15.	Winston-Salem, N.C.		

LET'S DO EVEN MORE!

Fill in the following on the map:

- a) isobars
- b) high-pressure center (H)
- c) low-pressure center (L)
- d) ball symbols
- e) temperatures

The air pressures are shown on Figure C.



10.	Portland, Maine	Snow	-1	30
11.	Salt Lake City, Utah	Clear	18	65
12.	San Diego, Calif.	Partly cloudy	28	82
13.	Santa Fe, N. Mex.	Clear	26	79
14.	Toronto, Ont.	Partly cloudy	2	35
15.	Tulsa, Okla.	Rain	20	68

16. The high-pressure area is in the _____ east, west.

17. The low-pressure area is in the _____ east, west.

WORD SEARCH The words in this list are hidden within the groups of letters. Try to find each word. When you find it, circle the word. The spelling may go backwards or forwards in any direction: up-and-down, across, or diagonally.

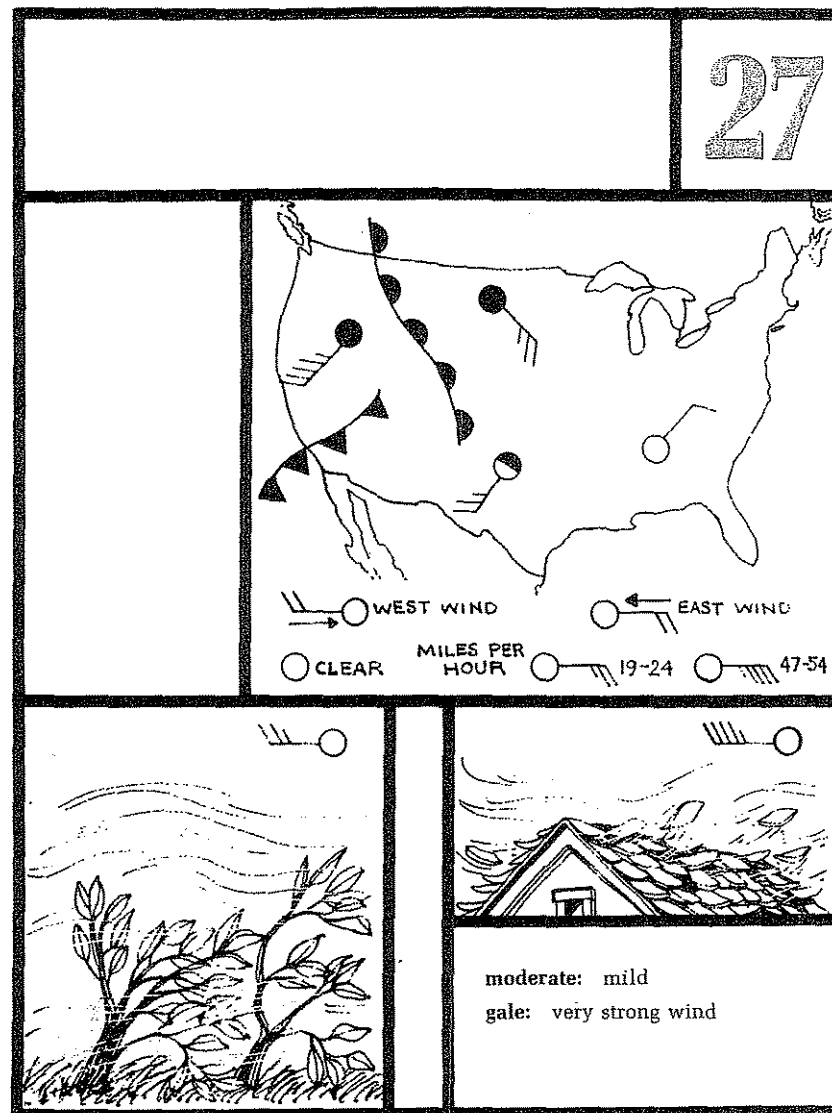
A	R	I	A	I	R	A	R	H	A	I	L	N	T
T	Q	U	R	T	B	S	U	T	Y	U	V	X	I
E	E	P	O	L	A	R	O	R	A	I	N	E	R
E	T	Q	Z	B	R	T	A	S	R	I	T	T	A
L	C	R	D	I	U	N	L	B	W	N	I	D	B
S	N	D	C	A	O	L	A	O	O	N	W	T	I
O	X	A	R	I	N	H	A	R	N	S	V	X	L
O	N	M	T	I	M	E	F	R	S	Z	I	M	L
E	M	A	P	R	E	D	I	C	T	I	O	N	I
I	T	S	I	G	O	L	O	R	O	E	T	E	M
S	Z	M	E	M	A	R	I	T	I	M	E	E	I

RAIN
SLEET
HAIL
SNOW
AIR
POLAR
MARITIME
FRONT

STATIONARY
PREDICTION
METEOROLOGIST
ISOBAR
MILLIBAR
HURRICANE

HOW DO WE SHOW WIND ON A WEATHER MAP?

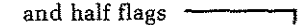
27



AIM | How do we show wind on a weather map?

27 | weather map?

Wind is an important part of weather. Wind is also an important part of a weather map.

The symbol for wind is a long line with small lines on the end. The small lines are called "feathers" or "flags." There are full flags  and half flags .

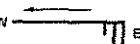
A wind symbol tells us two things:

- (1) how fast the wind is blowing
- (2) the direction it is coming from

WIND SPEED The number and length of the flags tell the wind speed. More flags mean faster wind. Fewer flags mean slower wind.

The chart on the facing page shows the wind speed symbols.

WIND DIRECTION A wind symbol looks like an arrow. And we use this fact to tell wind direction—THE ARROW FLIES WITH THE WIND.

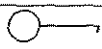
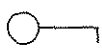
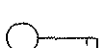
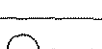
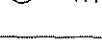
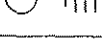
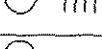
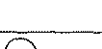
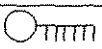
The tip points to . The feathers show where the wind is moving.  The feathers show where the wind is coming from.

This wind is heading west. It is coming from the east. It is called an east wind. (Remember, a wind is named for the direction it comes from.)

On most maps, a sky ball symbol is on the tip. For example:



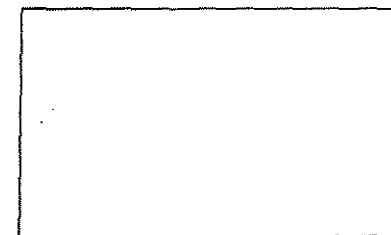
WIND CHART

Symbol	Speed		Description	What The Wind Does
	miles per hour	km per hour		
	less than 1 per hour	less than 2 per hour	calm	Smoke rises straight up
	1-3	2-5	light air	Smoke moves with the wind
	4-7	6-11	slight breeze	Face feels wind; leaves rustle; flags stir
	8-12	12-19	gentle breeze	Leaves and twigs in constant motion; light flags wave straight out
	13-18	20-29	moderate breeze	Dust clouds rise; paper and small branches move
	19-24	30-39	fresh breeze	Small trees bend; whitecaps form
	25-31	40-50	strong breeze	Umbrellas turn inside out; large branches move; telephone wires whistle
	32-38	51-61	near gale	Walking difficult; large flags blow straight out
	39-46	62-74	gale	Walking is extra difficult; twigs break off trees
	47-54	75-87	strong gale	Shingles torn off roofs
	55-63	88-101	storm	Trees and telephone poles topple; much damage to homes
	64-75	102-120	violent storm	Very heavy damage
	over 75	over 120	hurricane	Extra heavy damage

Measuring wind was first done by sailors on ships. They used different flags to show how strong the wind was blowing.

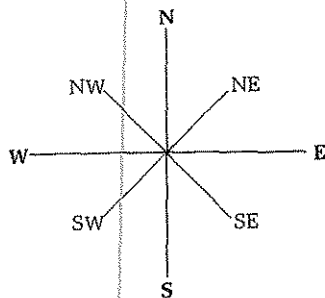
Now these symbols are used by the Weather Service to show wind on a map.

What is the strongest wind you have ever felt? Answer by drawing the symbol in the box.



WHICH DIRECTION?

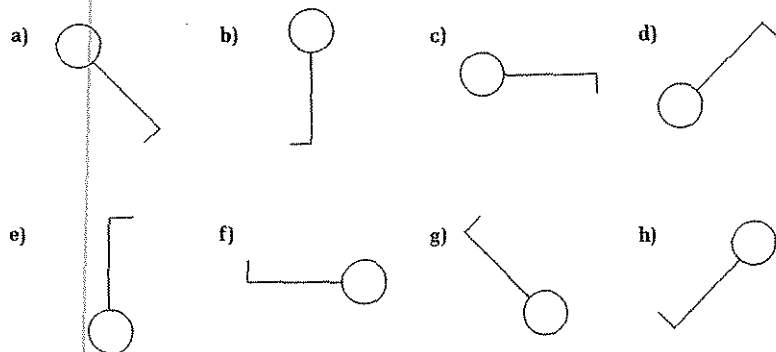
This chart gives some examples of how winds are named from their symbols.



Wind				
	Symbol	Moving Towards Which Direction?	Coming From Which Direction?	Name
1.		West	East	East
2.		North	South	South
3.		Southwest	Northeast	Northeast

After reading the chart above, complete these sentences.

- Wind moves _____ the ball symbol.
towards, away from
- A wind is named for the direction the wind is _____
heading, coming from
- Draw an arrow next to each of these symbols to show the wind direction. (Do not name the wind.)



"READING" WIND SYMBOLS

How fast are these winds blowing? Use the wind chart. Write your answers in the blank spaces.

Symbol	Wind Speed	Symbol	Wind Speed
1.		7.	
2.		8.	
3.		9.	
4.		10.	
5.		11.	
6.		12.	

What is the name of each wind? Write your answers in the blank spaces.

Symbol	Name	Symbol	Name
1.		5.	
2.		6.	
3.		7.	
4.		8.	

HURRICANE SYMBOLS

Both Figures A and B show hurricane symbols.



- What two things does symbol B tell you?
a) _____ b) _____
- Why is the second symbol better? _____

FILL IN THE CHART

Study the ten symbols shown below. Then fill in the missing information on the chart. The first one has been completed for you.

	Wind Symbol	Speed	Description	Name
1.		20-29 kph (13-18 mph)	moderate breeze	east wind
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

FROM MAP TO CHART

Study the symbols on the weather map (Figure C). Fill in the chart.

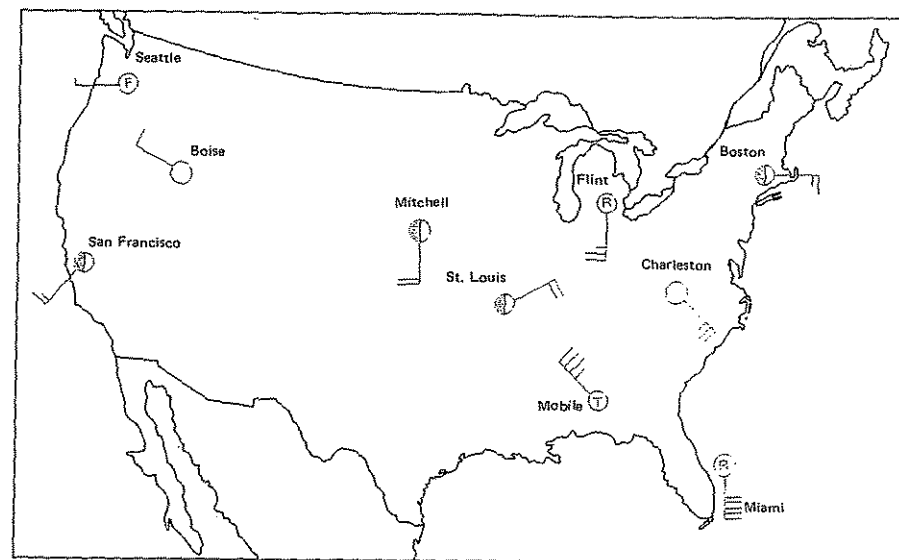
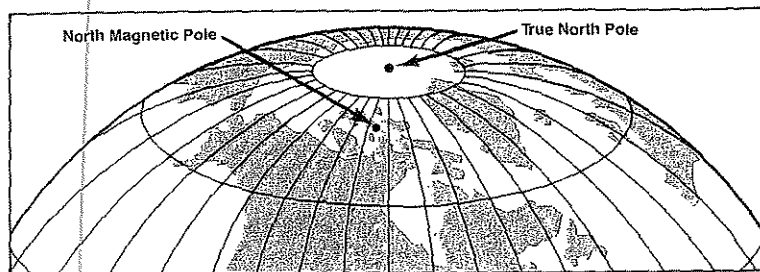


Figure C

	City	Sky Condition	Wind Speed	Wind Name	Wind Coming From	Wind Heading Towards
1.	Boise, Idaho					
2.	Boston, Mass.					
3.	Charleston, W. Va.					
4.	Flint, Mich.					
5.	Miami, Fla.					
6.	Mitchell, S.D.					
7.	Mobile, Ala.					
8.	San Francisco, Calif.					
9.	Seattle, Wash.					
10.	St. Louis, Mo.					

KEEPING UP WITH SCIENCE



THE RESTLESS MAGNET

Our planet makes a complete rotation on its axis once every day. The northern end of this axis is called the true north pole. The southern end is the true south pole.

The earth has another north pole, the north magnetic pole. The true north pole and the north magnetic pole are not at the same spot. There is also a south magnetic pole, in the Antarctic.

The true north pole stays in one place. But the north magnetic pole does not. It is always slowly moving. Every year the north magnetic pole moves about 15 miles. At present it is moving in a northwesterly direction. Its present location is under Hudson Bay, Canada. This is about 1,600 km (994 miles) from the true north pole.

Why does the earth act like a magnet? Deep in the earth, there is a layer of molten material. It is mostly iron and nickel. Scientists believe that this layer gives the earth its magnetic field.

The molten material "swishes" about as the earth rotates. As a result, the earth wobbles slightly as it turns. It is this wobble that causes the north magnetic pole

to slowly move instead of staying in one position.

The angle between the true north pole and the direction towards which a compass needle points is called magnetic declination. Declination is measured in degrees east and degrees west of the true north pole. The angle depends upon where you are on earth.

There are maps that show magnetic declination all over the earth. Lines on these maps are drawn through places that have the same declination. They are called isogonic lines. At declination zero, a compass needle pointing towards the north magnetic pole, is also pointing towards the true north. Most isogonic lines are not straight. This is because the earth's magnetic field is not straight everywhere. It curves a bit from place to place.

Declination maps are important for navigation. However, the locations of the earth's magnetic poles are always slowly changing. Therefore, the maps must also be changed. New declination maps are drawn once a year. Tables list predicted day-to-day changes for that year.

WHAT IS THE HYDROSPHERE?

28



hydrosphere: the part of the earth covered with water
climate: the usual kind of weather a part of the earth has
currents: movements of the ocean water

AIM | What is the hydrosphere?

28

Have you ever seen pictures of the earth taken from space? You can see clouds, land, and water. In fact, you see mostly water. Only 29 percent of the earth's surface is land. The rest—71 percent—is water. We call the water part of our planet the hydrosphere [HIDE rus fear].

Most of the hydrosphere is one huge ocean. But we think of it as four oceans. They are the Atlantic, Pacific, Indian, and Arctic.

The oceans are all connected. But each ocean has its own circulation, as you can see in Figure B. Around the edges of each ocean is moving water, or currents.

Most ocean currents are very slow and wide. (Tidal currents can be very fast.) Along the western margin of the North Atlantic Ocean is the Gulf Stream. And along the western margin of the North Pacific is the Japanese Current. These are the fastest ocean currents. They move between two and six miles (three and ten kilometers) an hour. They are much narrower than the other currents.

Figure B shows the major ocean currents. Notice their circular paths. Each one covers a great distance.

What causes ocean currents?

- The planetary winds are the chief cause of currents.
- The spinning of the earth causes currents to move at an angle.
- The continents (land) cause currents to turn.

The oceans and the atmosphere work together in many ways. As you know, air masses pick up water over oceans and bring rain to the land. But ocean currents also affect climate. Here is an example:

Find the Gulf Stream in Figure B. The Gulf Stream starts in a warm part of the earth. Gulf Stream water is warmer than the water next to it. Winds that blow over the Gulf Stream pick up some of this warmth and moisture. The warm, moist air blowing over the Gulf Stream brings mild weather with it.

THE HYDROSPHERE

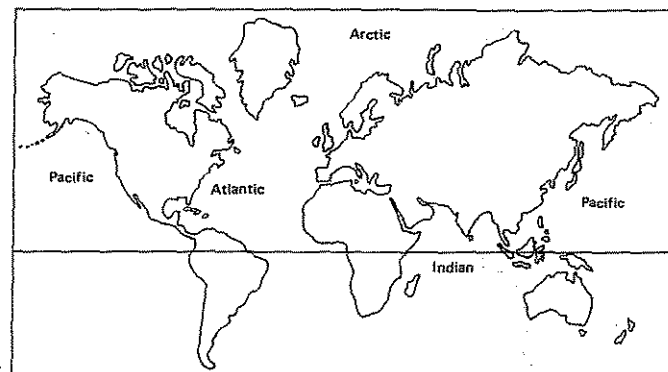


Figure A

Most of the earth's water is part of one huge ocean. But it has been divided into four separate oceans.

1. Name the oceans. _____
2. Look at Figure A. Which is the largest ocean? _____
3. About what percentage of the earth is water? _____
4. What do we call the earth's water layer? _____

OCEAN CURRENTS

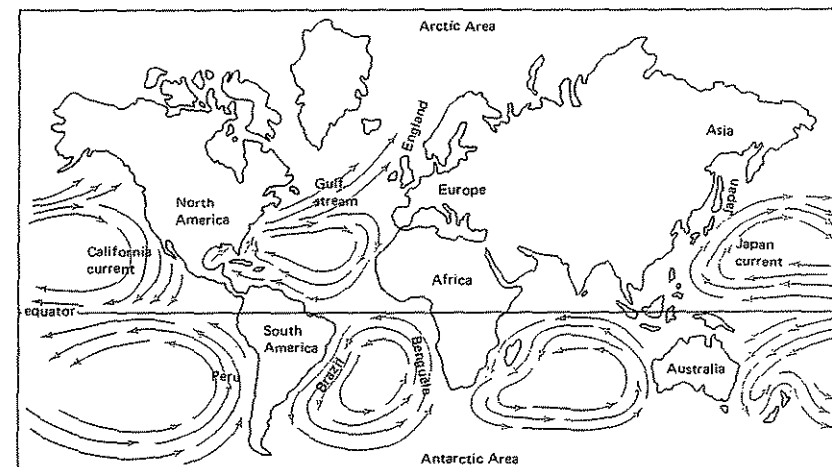


Figure B

The ocean currents are grouped into warm currents and cold currents.

1. Currents that come from near the equator (like the Gulf Stream) are

_____ currents.
warm, cold

2. Currents that come from the far North and the far South are _____ currents.
warm, cold

Use Figure B to answer these questions.

3. North of the equator, the ocean currents move in a _____ direction.
clockwise, counterclockwise
4. South of the equator, the ocean currents move in a _____ direction.
clockwise, counterclockwise

Follow the path of the Gulf Stream.

5. The Gulf Stream starts in the Gulf of Mexico where the water is _____.
warm, cold
6. The Gulf Stream flows _____ toward Europe.
northeast, southwest
7. It flows toward the coast of _____.
Japan, England
8. The Gulf Stream brings _____ toward England.
warm air, cold air
9. This helps to make the winters in England _____.
colder, warmer

Which current?

10. If you tossed a bottle into the _____ Ocean it could be washed up on the coast of Japan.
Pacific, Atlantic
11. It would be carried toward Japan by the _____ current.
Gulf Stream, Japan
12. If you tossed a bottle into the _____ Ocean it could be washed up on the coast of England.
Pacific, Atlantic
13. It would be carried toward England by the _____ current.
Gulf Stream, California

OCEAN CURRENTS AFFECT CLIMATE

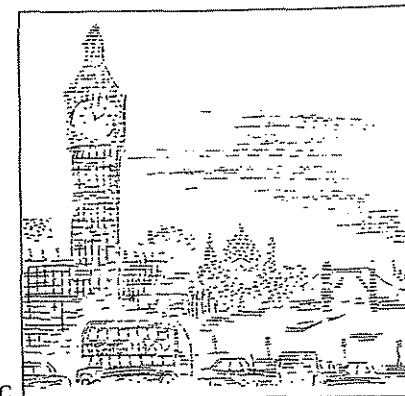


Figure C

London is famous for its "pea soup" fogs. They form when warm Gulf Stream water meets colder water off the English Coast.

OCEAN CURRENTS ALSO AFFECT SEA NAVIGATION

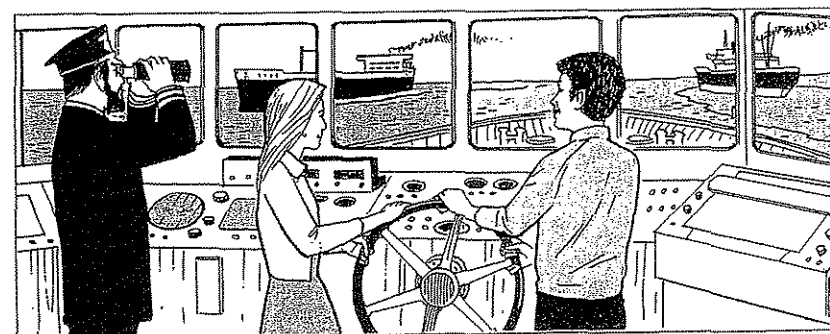


Figure D

Imagine that you are a ship's captain.

1. a) If you were sailing to England from the United States, you would _____ the Gulf Stream.
seek out, avoid
b) Why? _____
2. a) If you were sailing from England to the United States you would _____ the Gulf Stream.
seek out, avoid
b) Why? _____

COMPLETING SENTENCES Complete the sentences with the choices below.

continent
warm currents
ocean navigation
move at an angle
clockwise

cold currents
ocean currents
Arctic
equator

Antarctic
rivers of the oceans
climate
planetary winds

1. The general movements of the ocean waters are called _____.
2. Ocean currents have been called the "_____."
3. The chief cause of ocean currents is the _____.
4. The turning of the earth makes the currents _____.
5. An ocean current turns around when it comes near a _____.
6. In the part of the world you live, the ocean currents move in a _____ direction.
7. Ocean currents are classified as _____ and _____.
8. Warm currents start near the _____.
9. Cold currents start near the _____ and _____ areas.
10. Ocean currents affect _____ and _____.

WORD SCRAMBLE Unscramble each of the following to form a word or term that you have read in this Aim.

1. RUCTERN
2. SEERPHOHRDY
3. TINNONECT
4. NOCEA

WHAT DOES THE OCEAN FLOOR LOOK LIKE?

29

continental shelf: underwater part of a continent

ridge: underwater mountain

trench: deepest place in the ocean floor

AIM | What does the ocean floor 29 | look like?

The earth is sometimes called the "water planet." Other planets have water, but only in small amounts. The earth has 500 million cubic kilometers (120 million cubic miles) of water. Compared to this amount, other planets have practically nothing.

Most of the earth's water is found in our oceans. The oceans lie in huge basins. But the water spreads beyond the basins. It goes onto low parts of the continents. The part of a continent that is covered by the ocean is called the *continental shelf*.

The continental shelf slopes gradually downward.

At the end of the slope, the ocean floor drops sharply. This sharp drop is called the *continental slope*.

The basin begins at the bottom of the continental slope. The average depth of the deep-sea basin is 426 meters (1,400 feet).

If all the ocean water would suddenly disappear, what would you see? You would see many of the features found on land.

The ocean floor has flat areas. It also has mountains and canyons.

- The flat areas are called *plains*.

- The mountains are called *ridges*. Some ocean mountains are *volcanic mountains*.

- Submarine canyons are long valleys with steep sides. They are found along the continental shelf.

- The deepest parts of the ocean are called *trenches*. Most trenches are near chains of volcanic islands that are close to a continent.

THE OCEAN FLOOR

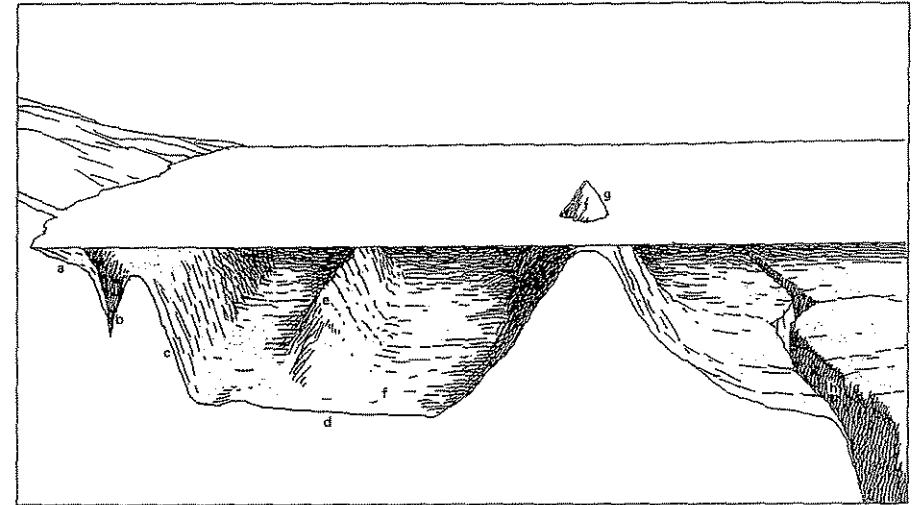


Figure A

Figure A shows features of the ocean floor. They are listed below. Identify each feature by letter.

- | | |
|----------------------------|---------------------------|
| 1. continental shelf _____ | 5. submarine canyon _____ |
| 2. continental slope _____ | 6. trench _____ |
| 3. deep sea basin _____ | 7. ridge _____ |
| 4. volcanic mountain _____ | 8. plain _____ |

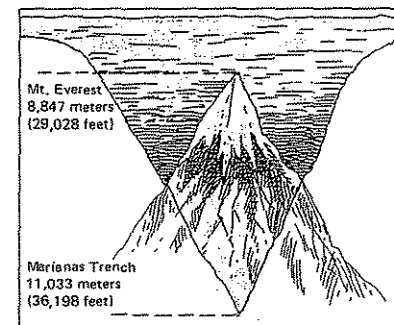


Figure B

Trenches are the deepest parts of our planet.

The deepest trench is the *Marianas Trench* in the Pacific. It reaches down 11,033 meters (36,198 feet).

Mount Everest is the earth's tallest mountain. The *Marianas Trench* is deeper than Mount Everest is high.

If Mount Everest were placed into the *Marianas Trench*, how many meters of water would be above its peak?

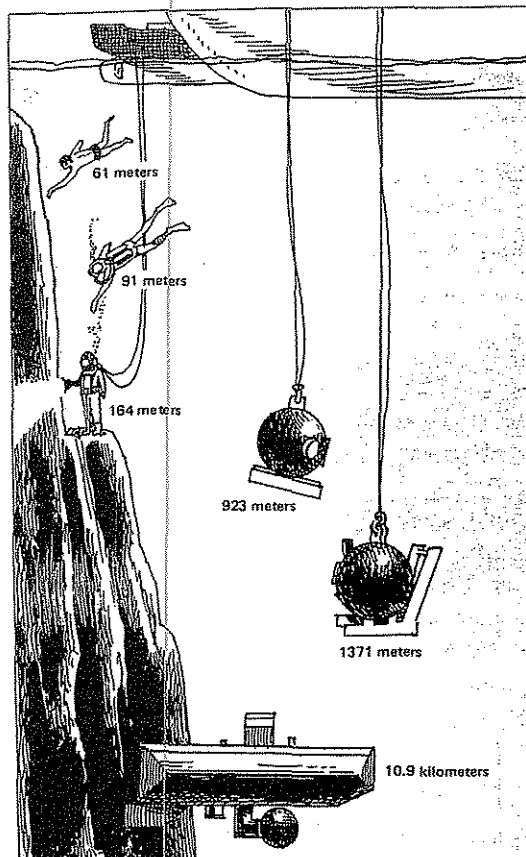
EXPLORING THE OCEAN FLOOR

People have always wanted to explore the ocean floor. Two things have made this exploration very difficult:

- 1) People can't breathe in water.
- 2) Water pressure is very great deep down in the ocean. It can easily crush a person.

Special equipment has been built. It lets scientists safely explore thousands of meters below the waves. Many important discoveries have been made.

How deep in the ocean can people go?



Without special equipment, about 61 meters (200 feet).

With tanks of compressed air, about 91 meters (300 feet).

Wearing a steel diving helmet and rubberized suit, about 164 meters (540 feet).

In 1934, Beebe and Barton reached a depth of 923 meters (3,028 feet). They were in a special "steel ball" submarine.

In 1949, Barton reached 1,371 meters (4,500 feet).

In 1960, the Trieste reached down 10.9 kilometers (nearly 7 miles).

This is the record—so far!

Figure C

LIVING UNDERWATER

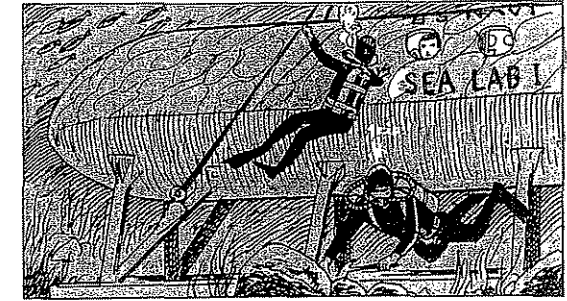


Figure D

The U.S. Navy wanted to find out how people could live and work deep underwater.

In 1964, Sea-Lab I was lowered 59 meters (193 feet) to the ocean floor. Four navy scientists lived and worked in it for 11 days. Every day they left the Sea-Lab to do different kinds of underwater tests.

Sea-Lab II followed in 1965. In 1969 Sea-Lab III rested on the ocean floor 182 meters (600 feet) deep. This is the deepest that people have lived and worked underwater.

COMPLETING SENTENCES

Complete the sentences with the choices below.

continental shelf
trenches
sharply
ridges

submarine
continental slope
oceans

Marianas
basins
gradually

1. Most of the earth's water is found in the _____.
2. Most of the oceans lie in huge _____.
3. The part of the continent that is under the ocean is called the _____.
4. The continental shelf slants _____.
5. At the end of the continental slope the ocean floor drops _____.
6. The deep-sea basin starts at the end of the _____.
7. Mountains in the ocean are called _____.
8. Valleys in the continental shelf are called _____ canyons.
9. The deepest places along the ocean floor are _____.
10. The deepest trench in the world is the _____ Trench.

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | | |
|----------|-------------------|---|
| 1. _____ | water planet | a) underwater mountain |
| 2. _____ | continental shelf | b) deepest part of the earth |
| 3. _____ | plain | c) flat area |
| 4. _____ | trench | d) low part of a continent covered by the ocean |
| 5. _____ | ridge | e) earth |

TRUE OR FALSE Write T on the line next to the number if the sentence is true. Write F if the sentence is false.

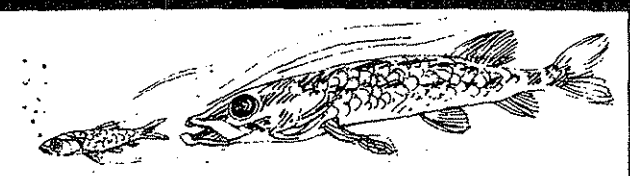
1. _____ The earth is the only planet.
2. _____ Only our planet has a lot of water.
3. _____ The earth's water layer is called the atmosphere.
4. _____ The continental shelf has a gentle slant.
5. _____ The continental slope has a gentle slant.
6. _____ The deep sea floor starts at the beginning of the continental shelf.
7. _____ A ridge is a high place on the ocean floor.
8. _____ A submarine canyon is a low place on the ocean floor.
9. _____ A submarine canyon is deeper than a trench.
10. _____ The ocean floor has some flat places.

REACHING OUT

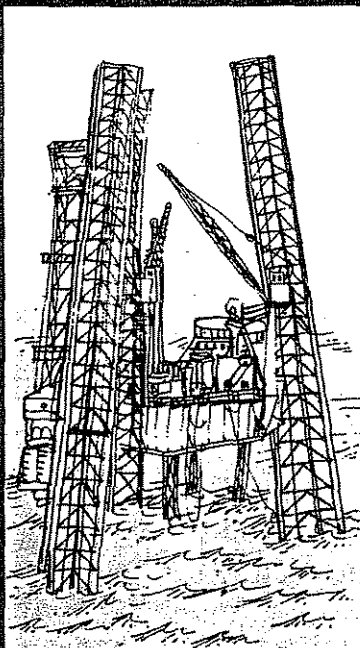
One state of the United States was formed entirely from several volcanoes that rose from the ocean floor.

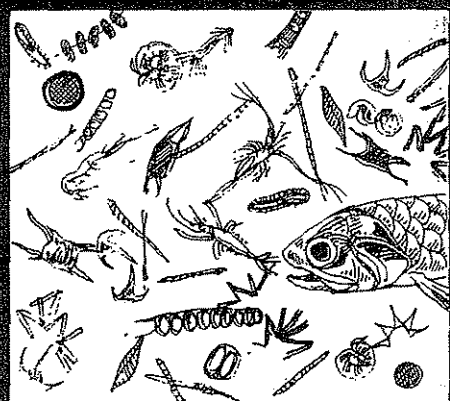
What is the name of this state? _____

WHY ARE THE OCEANS IMPORTANT?



30





phytoplankton: tiny green plants from the ocean

minerals: important chemicals

AIM | Why are the oceans 30 | important?

The oceans are more important than you may think. Without the oceans, there would probably be no life on earth. The oceans and the atmosphere work together to support living things. This is how:

Living things must breathe oxygen. This oxygen comes from green plants. Green plants that grow on land supply some oxygen to the air but only a small amount. Most of the oxygen of the air—about 80 to 90 percent—comes from microscopic sea plants called phytoplankton [fite oh PLANK tun]. (Surprised?) Phytoplankton also supply oxygen to ocean water. Sea animals, as well as sea plants, use this oxygen.

There is another way in which the oceans and the atmosphere work together. Water evaporates from the oceans to form clouds. The clouds move over land. The moisture leaves the clouds in the form of rain or snow. Then, the plants and animals get the water they need.

The oceans are important in other ways too.

The oceans give us food. Fish and shellfish are two important foods we get from the seas. Millions of people in Asia and the Pacific islands also eat ocean plants called seaweed.

The oceans give us oil and gas. Large deposits of oil have been found in the ground along the continental shelf. And usually, where there is oil, there is also natural gas.

The oceans give us minerals. Ocean water contains every known mineral. The most common one is, of course, salt. This is also called sodium chloride. It is taken from the ocean to be used in many ways. Other minerals that are taken from the sea are manganese and bromine. Still other minerals dissolved in the ocean are not used. It costs too much to take them out.

PHYTOPLANKTON

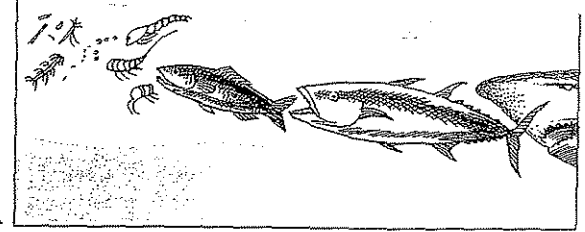


Figure A

Phytoplankton are plants. There are other kinds of plankton. They are microscopic animals called zooplankton [zoe uh PLANK tun]. Both types of plankton are the start of the ocean food chain. It works something like this:

- Tiny sea creatures eat the microscopic plankton.
- Small fish eat the tiny creatures.
- Larger fish eat the small fish.
- Still larger fish eat the large fish . . . and so on.

Actually, not only fish take part in this food chain. All sea animals are involved. They include octopus, shellfish, and sea mammals like seals, dolphins, and whales.

How do people fit into this food chain? _____

SOMETHING INTERESTING

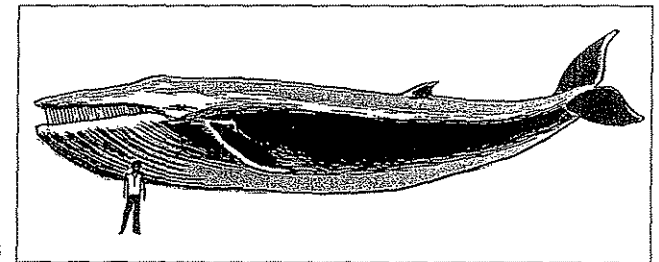


Figure B

Plankton are among the *smallest* life forms in the sea.

Whales are the *largest*. In fact, whales are the largest animals that ever lived.

The largest whale is the blue whale. It may grow 29 meters (95 feet) long and weigh 136 metric tons (150 tons).

The huge blue whale is a baleen whale. Baleen whales eat mostly plankton—about ½ to 1½ tons every day.

Without microscopic plankton, the world's largest animals would die out.

"GIFTS" FROM THE SEA

Some fish do not taste good. People do not eat them. But they are still important. They have valuable nutrients—especially protein.



Figure C

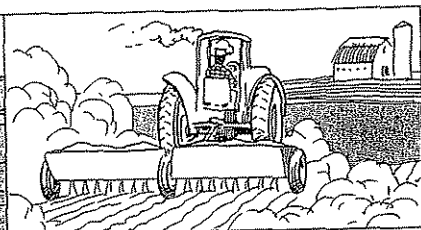


Figure D

Some of these "trash" fish are made into fertilizer. How does this help farmers?



Figure E

Others are made into "fish flour." Fish flour doesn't taste "fishy." It can be added to simple foods like soup.

Fish flour is a cheap way for poorer people to get needed protein.

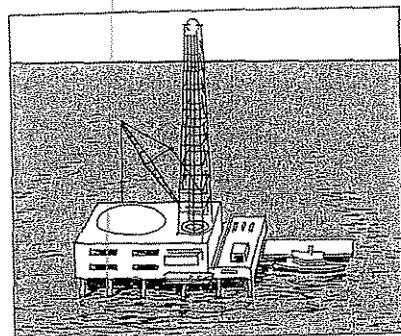


Figure F

Drilling for offshore oil.

In shallow offshore waters, drilling is done from permanent platforms. The platforms have legs that are sunk into the ocean floor.

In deeper water, floating platforms and special drilling ships are used.

Scientists believe that there is more oil below the oceans than there is below land.

What special problem does offshore drilling present? _____

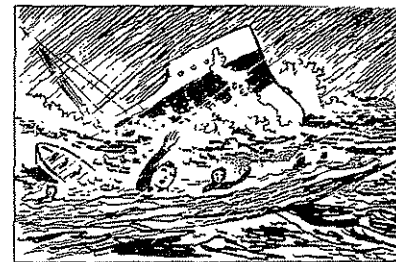


Figure G

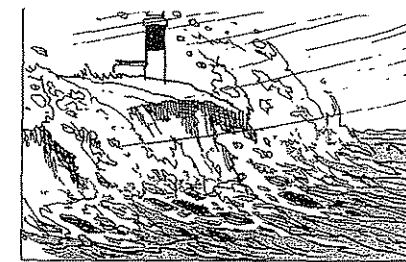


Figure H

The ocean is not always helpful or "nice."

Angry seas have "swallowed up" countless thousands of ships—along with their passengers and crews.

Pounding waves wear away the coastlines.

What can be done to keep the wearing away from happening? _____

WHY IS THE OCEAN SALTY?



Figure I

Oceans get their salt and other dissolved materials from the land. Rainwater dissolves minerals and salts (including table salt) as it moves through the ground.

The water goes into rivers and streams. Sooner or later, the water empties into the oceans.

COMPLETING SENTENCES

Complete the sentences with the choices below.

eat	bromine	mineral
salt	seaweed	fertilizer
fish flour	costs too much	fish
phytoplankton	dead	manganese
shellfish	oil and gas	ocean
rain and snow		

- Most of the oxygen we breathe comes from microscopic green plants called _____.
- Plankton live in the _____.
- The oceans supply most of the vapor that returns to earth as _____.
- Without the oceans, our planet would be a _____ planet.
- People eat many things that live in the ocean. Three examples are _____, _____, and _____.
- "Trash" fish are fish that are not good to _____. They are made into _____ and _____.
- Large deposits of _____ have been discovered along coastal waters.
- Ocean water contains every known _____.
- Every 4 cubic kilometers (1 cubic mile) of seawater contains 18 kilograms (40 lbs.) of gold. We don't take it out because it _____ to remove.
- Three minerals we do take from sea water are _____, _____, and _____.

A THOUGHT FOR YOUR FUTURE

You have learned about some of the "gifts" from the oceans. But, what have people given to the oceans in return?

Oil spills, garbage, wastes from factories and ships . . .

The oceans must be used thoughtfully. Protecting them from pollution protects our future.

MATCHING Match the two lists. Write the correct letter on the line next to each number.

- | | |
|-----------------------------------|--|
| 1. _____ phytoplankton | a) minerals we take from the sea |
| 2. _____ zooplankton | b) high-protein source for many poor people |
| 3. _____ salt, manganese, bromine | c) supply most of the oxygen to the atmosphere |
| 4. _____ fish flour | d) change coastlines |
| 5. _____ waves | e) microscopic sea animals |

TRUE OR FALSE Write T on the line next to the number if the sentence is true. Write F if the sentence is false.

- _____ Green plants give off oxygen.
- _____ All green plants grow on land.
- _____ There are more green plants in the ocean than there are on land.
- _____ Most of our oxygen comes from phytoplankton.
- _____ Phytoplankton are large.
- _____ The ocean is an important source of food.
- _____ Seaweed is a food.
- _____ Most below-water oil deposits are in the deep-sea basin.
- _____ Every mineral we use comes from the ocean.
- _____ Huge amounts of water evaporate from the ocean. This means that the oceans are drying out.

REACHING Many people earn their living from the sea.

OUT

How many different kinds of jobs can you name that depend upon the sea?

SPELL THE MISSING WORD Fill in the missing letters to spell the terms that fit the definitions. When you have answered correctly, you will spell another term in the box.

1.		x		g		n
2.		l		u		s
3.	s	a		e		d
4.	s	l				
5.	p	a	k		o	

1. a gas made by plants
2. where rain comes from
3. plant from the sea that can be eaten
4. common mineral in the ocean
5. microscopic sea life

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2.		l		u		s
3.	s	a		e		d
4.	s	l				
5.	p	a	k		o	

1. a gas made by plants
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